“Commercial Demonstration of the Manufactured Aggregate Processing Technology Utilizing Spray Dryer Ash”

Final Technical Report

Reporting Period Start Date: November 14, 2002

Reporting Period End Date: December 31, 2006

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Date Issued: November 12, 2007

DOE Award No: DE-FC26-02NT41421

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Disclaimer

Abstract

Universal Aggregates LLC (UA) was awarded a cost sharing Co-operative Agreement from the Department of Energy (DOE) through the Power Plant Improvement Initiative Program (PPII) to design, construct and operate a lightweight aggregate manufacturing plant at the Birchwood Power Facility in King George, Virginia in October 2001. The Agreement was signed in November 2002. The installation and start-up expenses for the Birchwood Aggregate Facility are $19.5 million. The DOE share is $7.2 million (37%) and the UA share is $12.3 million (63%). The original project team consists of UA, SynAggs, LLC, CONSOL Energy Inc. and P. J. Dick, Inc. Using 115,000 ton per year of spray dryer ash (SDA), a dry FGD by-product from the power station, UA will produce 167,000 tons of manufactured lightweight aggregate for use in production of concrete masonry units (CMU). Manufacturing aggregate from FGD by-products can provide an economical high-volume use and substantially expand market for FGD by-products. Most of the FGD by-products are currently disposed of in landfills.

Construction of the Birchwood Aggregate Facility was completed in March 2004. Operation startup was begun in April 2004. Plant Integration was initiated in December 2004. Integration includes mixing, extrusion, curing, crushing and screening. Lightweight aggregates with proper size gradation and bulk density were produced from the manufacturing aggregate plant and loaded on a stockpile for shipment. The shipped aggregates were used in a commercial block plant for CMU production. However, most of the production was made at low capacity factors and for a relatively short time in 2005. Several areas were identified as important factors to improve plant capacity and availability. Equipment and process control modifications and curing vessel clean up were made to improve plant operation in the first half of 2006. About 3,000 tons of crushed aggregate was produced in August 2006. UA is continuing to work to improve plant availability and throughput capacity and to produce quality lightweight aggregate for use in commercial applications.

Acknowledgements

Universal Aggregates, LLC wishes to acknowledge the following organizations for their continued support:

U.S. DOE / NETL
Trumbull Corporation / P.J. Dick Incorporated / Lindy Paving
Birchwood Power Partners, LP
Versalite Sales of Virginia
Consol Energy, Inc.
R.T. Patterson, Inc.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

List of Drawings

Glossary of Terms

ASTM	American Standard for Testing Materials
AWWA	American Water Works Association
BMAP	Birchwood Manufactured Aggregate Project
BPF	Birchwood Power Facility
BPP	Birchwood Power Partners
CBPA	Chesapeake Bay Preservation Act
CCT	Clean Coal Technology
DEQ	Virginia Department of Environmental Quality
DOE	U.S. Department of Energy
E & S	Erosion and Sedimentation Plan
FGD	Flue Gas Desulfurization
° F	Degrees Fahrenheit
GPD	Gallons Per Day
GPM	Gallons Per Minute
H_2O	Water
I/O	Input / Output
KV	Kilovolts
LB/FT^3	Pounds Per Cubic Foot
LB/HR	Pounds Per Hour
OIT	Operator Interface Terminal
PLC	Programmable Logic Controller
PPII	Power Plant Improvement Initiative
RPA	Resource Protection Act
SCFM	Standard Cubic Feet Per Minute
SDA	Spray Dryer Ash
SIC	Standard Industrial Code
UA	Universal Aggregates, LLC
VDH	Virginia Department of Health
VPDES	Virginia Pollutant Discharge Elimination System
WQD	Water Quality Volume

EXECUTIVE SUMMARY

Background

Universal Aggregates LLC (UA) is demonstrating a process to produce manufactured aggregates from coal combustion by-products (CCBs) from dry and wet flue gas desulfurization (FGD) processes, fluidized-bed combustion (FBC) and pulverized coal (p. c.) combustion. The aggregate production process has been developed in bench- and pilot-scale to produce specification aggregates for use in construction since 1990. In October 2001, UA was awarded a cost sharing Co-operative Agreement from the Department of Energy (DOE) through the Power Plant Improvement Initiative Program (PPII) to design, construct and operate a lightweight aggregate manufacturing plant at the Birchwood Power Facility in King George, Virginia. The Agreement was signed in November 2002. In the agreement, the installation and start-up expenses for the facility are $19.5 million. The DOE share is $7.2 million (37%) and the OA share is $12.3 million (63%). The original project team consists of UA, SynAggs, LLC, CONSOL Energy Inc. and P. J. Dick, Inc. At design capacity, Universal Aggregates will consume about 115,000 ton per year of spray dryer ash (SDA), a dry FGD by-product, from the power station, and produce about 167,000 tons of manufactured lightweight aggregate. The project will enable UA to demonstrate commercially its process that will convert SDA into lightweight aggregate for use in production of concrete masonry units (CMU). Manufacturing aggregate from FGD by-products can provide an economical high-volume use and substantially expand market for FGD by-products. Most of the FGD by-products are currently disposed of in landfills.

Plant Start-up

After the Cooperative Agreement was signed, engineering design of the Birchwood manufactured aggregate plant was initiated in November 2002. Construction began in March 2003 and the plant was completed in March 2004. Startup of the facility was undertaken in April 2004. The process covers large-scale integrated operation of mixing, extrusion, curing, crushing and screening. The new manufacturing facility also incorporates automatic programmable logic controls, process trending and data recording. The operating staff undertook many challenges during startup period including, but not limited to; an inexperienced staff, construction bugs, process control problems, material handling difficulties and ash quality issues. Universal Aggregates obtained continuous extrusion operation in July and then again in September 2004. The curing vessel was initially charged with green extrudants in October 2004 and again in December 2004. Production rates were lower than design capacity, mainly due to free flow problem of the aerated SDA at relatively high throughput, resulting in extruder operation problems.

When pneumatically conveyed from the Birchwood Power Plant (BPP) silo to the UA manufactured aggregate plant SDA day bin, the SDA becomes aerated and can cause free-flowing conditions and loss of mass flow control through the weigh feeders. The extruder was designed to handle clay not SDA. SDA has thixotropic properties with different mixing characteristics and compressibility, as compared to clay. Nevertheless, the plant achieved integrated operation for aggregate production in December 2004 and continued into January, February and March of 2005, for relatively short periods of time and at low capacity factors. During these periods, equipment and process control modifications were made to insure continuous operation. A quality assurance and control program was implemented for monitoring ash and aggregate qualities and process performance. Assistance was provided to the Birchwood Power Plant to implement a spray dryer modification program for lime optimization to reduce hydrated lime content in the SDA and improve the consistency of ash quality in September 2004.

Since start-up operation began, UA demonstrated that the process does work by producing over 1,000 tons of manufactured lightweight aggregates from December 2004 to Match 2005. The aggregates with proper size gradation and bulk density were produced and loaded on a stockpile for shipment. The aggregates were sold through a regional broker and used successfully by a Maryland masonry producer in production of concrete masonry units. The milestone of 24 hours continuous operation as requested by DOE was achieved on December 12 and 13 2005. However, most of production was made at low capacity factors and for a relatively short time in 2005.

Plant Modifications

During start-up operation, several areas were identified as important factors to improve plant capacity and availability. These areas include modification of the weight feeder outlet, enhancement of mixing in the pug mill, adjustment of pugsealer speed, refinement of the liner and die geometry in the extruder, and the pug sealer, improvement to evenly distribute the charge of green extrudants into the curing vessel and elimination of lump formation throughout curing vessel operation, improvement in dust control for the curing vessel recirculation circuit, and the separation of process control loops for operation. Mechanical discharge of the SDA weight feeder was required to prevent the aerated SDA from free flowing, and to achieve accurate control of the SDA feed at high throughput. Enhancement of mixing can minimize the adverse effect of thixotropic properties of the SDA and make wetted SDA cohesive for extrusion. Refinement of the liner and die geometry can increase the extruder operability to extrude wetted SDA. Even distribution of green extrudants and elimination of lump formation can insure continuous operation of the curing vessel in mass flow mode and at high throughput capacity. Improvements in dust control during curing vessel recirculation can keep plant operation in clean and safe environments. The separation of the process control loops provides plant operators optimum process control.

Equipment and process control modifications and curing vessel clean up were made to improve plant operation in the first half of 2006. Production was resumed in late July 2006. About 3,000 tons of crushed aggregate was produced in August 2006. Total aggregate production was over 9,000 tons in 2006. The plant availability for aggregate production remains limited by the amount of recycle, which can be incorporated as a mix component in pugmill. A double shaft pugmill was designed and installed in February 2007. This upgrade would be used to improve mix quality, increase capacity, and in turn process all generated recycle for full integration. UA is continuing to work to improve plant availability, throughput capacity, and produce quality aggregate for use in commercial applications.

Currently, the demonstration plant operates at 50% to 60% design capacity on a daily basis after installation of the double shaft pugmill. Additional equipment modifications and upgrades are continuing to improve operating capacity.

Manufactured aggregates are sold to several regular customers for use in the production of concrete masonry.

1.0 INTRODUCTION

1.1 Purpose of the Project Performance and Economics Report

The submittal of the Final Project Performance and Economics Report is a requirement of the PPII Cooperative Agreement.

The report provides a comprehensive synopsis of the project's background and history, a description of the project site and the technology employed, and provides updated information on capital expenditures, technical performance, estimated operating economics, and marketability of the demonstration technology.

Operating economic projections are of limited value due to the brief operating experience to date.

1.2 Overview of the Project

1.2.1 Background and History of Project

The PPII was established on October 11, 2000 as a follow-up to the DOE 's successful Clean Coal Technology (CCT) programs of the 1980's and 1990's, for the purpose of demonstrating, on a commercial scale, the advanced coal-based technologies applicable to both existing and new power plants. On September 26, 2001 the UA, Birchwood Manufactured Aggregate Project (BMAP) was selected for negotiations leading to the award of a cooperative agreement in November of 2002.

UA was formed as a joint venture on January 1, 2000 between CONSOL Energy, Inc. and SynAggs LLC, both Pittsburgh, Pa. based companies. CONSOL Energy is the largest bituminous coal producer east of the Mississippi River and the largest exporter of coal in the United States. SynAggs LLC ownership brings to the joint venture their expertise in heavy highway construction, building trade construction and construction management, including material handling and innovative beneficial ash utilization. In December 2003, the interest of the CONSOL Energy, Inc. partner was purchased by SynAggs LLC.

Conversion of SDA solids to manufactured aggregates has been demonstrated by Universal Aggregates in bench–scale, semi–continuous operations, and continuous fully integrated pilot plant production. Since 1995 Universal Aggregates has produced manufactured aggregates from the by–products of several spray dryers including the Birchwood Power Facility in pilot plant operation. The technology was ready for commercial demonstration.

In June 2001, 2.8 tons of cured extruded products were produced with bench–scale equipment from the Birchwood Power station's SDA by–products in semi–continuous production runs. The cured extruded products were crushed and screened for aggregate products of desired gradation. The crushed and sized aggregate was used for a concrete masonry production demonstration at a commercial block producer located in central Maryland. The properties of the concrete masonry units (CMUs) made from the manufactured lightweight aggregate met the ASTM specifications for medium–weight concrete masonry units.

In August 2001, 27 tons of cured extruded products were produced in the continuous 500 lb/hr. pilot plant from the Birchwood Power Plant SDA by–product. The crushed aggregate produced met the ASTM C331 lightweight aggregate specification. The crushed aggregates produced with different mix designs were used for a concrete masonry production demonstration at two commercial block producers, one located in central Maryland and the other located in northern Virginia. Demonstration testing with several CMU producers' block mix designs was also conducted at the National Concrete Masonry Association's laboratory in Herndon, Virginia. The properties of the CMUs indicate that manufactured aggregates made from the Birchwood Power Station's spray–dryer ash can be used as lightweight aggregates to replace or supplement conventional lightweight aggregates for medium weight CMU production in the market area.

1.2.2 Project Organization

Universal Aggregates, LLC
50/50 Joint Venture Partnership
SynAggs, Inc. & CONSOL Energy, Inc.

U.S. Department of Energy
Office of Fossil Energy

$12.3 MM

$7.2 MM

Power Plant Improvement Initiative (PPII)
"The Commercial Demonstration of the Manufactured Aggregate Technology Using Spray Dryer Ash"
($19.5 MM Project Est.)

Commercial Demonstration Site
Birchwood Power Station
King George, Virginia

Universal Aggregates, LLC
Designs and Builds Commercial Demonstration Project

SynAggs, LLC
Purchases interest of former joint venture partner, CONSOL Energy, Inc.

Universal Aggregates, LLC
Performs start – up, and operation of commercial demonstration

1.2.3 Project Description

The plant comprises of two metal buildings set upon concrete foundations; the “Process Building” and the “Curing Vessel” Building.

These two buildings are connected by two conveyor belts; one conveyor takes processed SDA (extruded) to the curing vessel, and the other conveyor moves cured aggregate from the curing vessel discharge back to the process building for crushing and screening. The finished aggregate is conveyed to a radial stacking conveyor for stockpile. Trucks enter the site, and the tare weight is recorded by the automated scale and ticketing system. An articulated, front-end loader loads the truck, and the truck returns to the scale for gross and net weight measurement and is ticketed before leaving the site for delivery to the customer.

The Process Building is also connected to the power station’s ash storage silo via an elevated pneumatic transfer line. The ash transfer pipeline, the process water line and a steam supply line are all enclosed upon the pipe bridge leading from the power station to Universal Aggregates’ Process Building. Section two (2), describes the demonstration site, the project and the equipment in more detail.

Demonstration plant construction photo and demonstration plant operating photo are shown in Pages P-1 to P-6.

1.2.4 Site

Universal Aggregates LLC’s manufactured aggregate facility is located on approximately Five (5) acres, immediately north of the main Birchwood Power Facility. The Birchwood Power Facility sits on approximately 345 acres adjacent to route 665 in the Northwest section of King George County, Virginia.

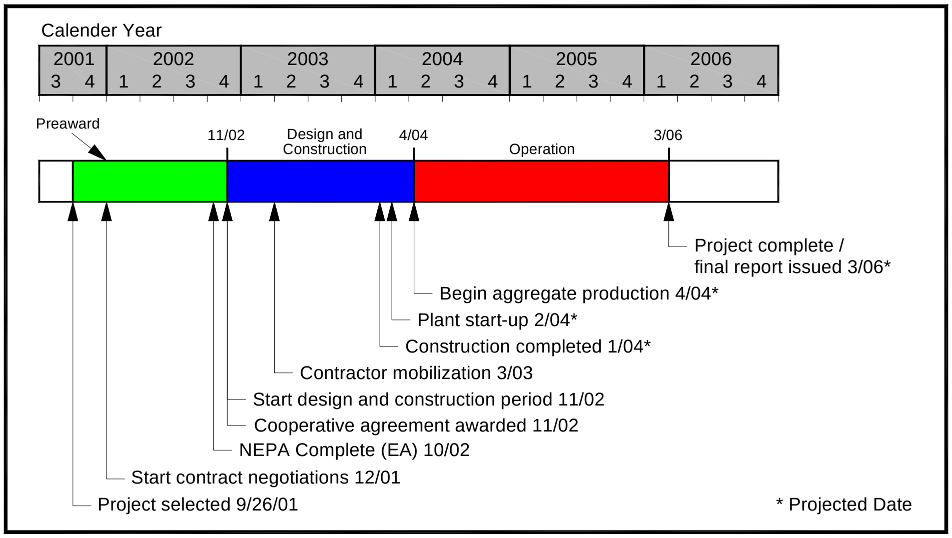
The Birchwood Power Facility consists of a single unit with a nominal capacity of 250 Mwe. Steam is supplied by a tangentially–fired, dry–bottom boiler that came on line in 1996. The plant includes low NOx burners and an SCR for NOx control, a baghouse for particulate control and a spray dryer absorber for SO_2 control. The boiler is fired with low–sulfur, bituminous coal.

See Appendix “A”, Drwgs. No. 001 – GA – 001, and 001 – GA – 002.

1.2.5 Project Schedule

The following presents the major milestones of the proposed construction schedule:

Contractor mobilization mid March 2003.
Construction completed end of January 2004.
Plant start-up February 1, 2004.
Production April 2004.



The project was granted two “no cost” time extensions. The current project completion date was December 31, 2006. Draft of final reporting was due to DOE March 31, 2007.

1.3 Objectives of the Project

Universal Aggregates LLC designed, constructed, and currently operates a lightweight aggregate manufacturing plant at the Birchwood Power Plant, located in King George, Virginia, according to the Co-operative Agreement

The USDOE provided approximately 37% of the $19.6 million of the original estimated project cost (about $7.2 million), with the industrial participant providing the remainder of the cost.

Full–scale commercialization of the project will convert up to 115,000 tons of SDA originally generated at the Birchwood facility into 167,000 tons of lightweight aggregate for use in the manufacture of lightweight/medium weight concrete masonry block or lightweight concrete.

1.4 Significance of the Project

The successful demonstration of the manufactured aggregate technology would offer power generators an alternative to landfilling by converting their waste into a highly beneficial product. The U.S. market for construction aggregates is currently 2 billion tons.

A successful demonstration could also result in the construction of additional lightweight aggregate manufacturing facilities in the U.S. There are 21 spray–dryer facilities currently operating in the United States that produce an adequate amount of SDA to economically justify installation of other lightweight aggregate manufacturing facilities. As additional scrubbing of coal–fired power plant flue gas is required, dry FGD technologies will become the technology of choice for power plants with capacity of less than 300MW.

The proposed project would create new manufacturing jobs, and further supplement transportation jobs for delivery of aggregate to customers.

Additional environmental benefits from the implementation of this technology include a reduction in landfilling of FGD waste, and a reduction in the impacts associated with mining materials and energy consumption used to produce expanded clay/shale–based lightweight aggregates.

1.5 DOE's Role in the Project

The U.S. DOE provided funding through a Cooperative Agreement, awarded as part of the "Power Plant Improvement Initiative" (PPII).

The "Power Plant Improvement Initiative" was the U.S. Government's first major competition for industry–proposed clean coal technology demonstration projects since 1992 - 93. The program attracted 24 candidate projects by the April 19, 2001, proposal deadline.

In the FY 2001 appropriations for the Department of Energy's Fossil Energy technology programs, the U.S. Congress provided funding from prior year Clean Coal Technology funds for the "commercial scale demonstration of technologies to assure the reliability of the Nation's energy supply from existing and new electric generating facilities".

On September 28, 2001, the US DOE selected eight projects for negotiation. Five projects, valued at nearly $83 million, requested nearly $32 million from the federal government.

Universal Aggregates LLC project, “The Commercial Demonstration of the Manufactured Aggregate Processing Technology Utilizing Spray Dryer Ash” was one of those eight selected demonstration projects.

2.0 TECHNOLOGY DESCRIPTION

2.1 Description of the Demonstrated Technology

The Universal Aggregates, LLC process converts Flue Gas Desulfurization (FGD) scrubber by-product materials into manufactured construction aggregates. The process tailors aggregate properties to specific applications, such as aggregates for manufacture of lightweight concrete blocks, structural lightweight concrete, or aggregates for use in asphalt road paving. The process consists of mixing, extrusion, moderate-temperature curing, crushing and screening. It takes advantage of the cementitious properties of the extruded products for strength development. Optimizing the water addition and time during the mixing step, in addition to identifying the proper conditions for curing are important factors for the production of aggregates with high strength and other desirable properties for use in construction. A proprietary curing method has been developed to optimize aggregate strength. The Universal Aggregates process represents an advance in the state of the art, and as a result was granted two U.S. patents (others are pending).

SDA, water, additive, and recycle material are fed to a pug mixer where the materials are blended together. This mixing produces a uniformly blended loose, moist, granular material that feeds directly to an extruder. The extruder has an auger that subjects the material to further mixing and then forces the material through a die (metal plate with one or more drilled or specially shaped holes).

Wet, "green" pellets (or extrudates) from the extruder are soft and must be transferred to a curing vessel for hardening. A belt conveyor transfers the short, soft, wet extrusions ("green" pellets) to a large slow turning tumbler where the pellets are tumbled with embedding material, which is a blend of SDA and additive #2. The green pellets and embedding material discharge from the tumbler to a belt conveyor that feeds the curing vessel. The purpose of the embedding material is to coat the green pellets with dry material and to fill in the void spaces between the pellets. This cushions the pellets as they move through the curing vessel and prevents agglomeration of the curing vessel charge by minimizing contact between green pellets.

The curing vessel is a specially designed retention bin that provides for flow of solids without channeling or hang-up. To minimize system heat losses, the vessel is also heat traced and insulated. The heat tracing is not used to raise the solids temperature, but provide enough heat to insure that the curing vessel operates adiabatically. The vessel is operated at a slight vacuum. The small amount of vent gas from the curing vessel is directed through a scrubber to remove particulate matter.

The pellets cured or harden as they slowly move down through the vessel. The hardening is a result of cementitious and/or pozzolanic reactions occurring within the green pellets. The formation of ettringite, a mineral with the formula $Ca_6A1_2(SO_4)_3(OH)_{12}{\cdot}26H_2O$ or $Ca_6A1_2(SO_3)_3(OH)_{12}{\cdot}26H_2O$, is thought to be responsible for much of the pellet hardening. SDA contains the essential components for the formation of ettringite. After curing, the hardened pellets screened to remove fines and sent to screening and crushing operations for aggregate production.

Screened pellets are fed to the crushing section. The crusher reduces the size of the cured pellets to a size suitable for use by concrete block plants. The crushed material feeds a screen that splits the crushed aggregate into three streams: oversize material, product, and fines. The oversize material (i. e., +3/8") feeds back into the system through a bucket elevator to the crusher and is recycled to extinction. The middle screen product, which is predominately 3/8" x 18 mesh, is sent to a stockpile via a belt conveyor/stacker. The –18 mesh fines go to an inertial separator that uses air classification to efficiently strip -100 mesh fines from the coarser fines. The -100 mesh fines from the inertial separator are collected in the baghouse and are recycled back to the process. The 18 x 100 mesh fines were sent to the stockpile as products. In setting up the crushing system, efforts are made to minimize the production of fines and the need for fines recycle. The Process Flow Diagram is shown on Figure 1. See Section 3.2 for the "Updated Equipment List".

2.2 Description of the Demonstration Facilities

General

The site layout of the Birchwood Manufactured Aggregate Plant is shown on Drawing 001-GA-002. The aggregate plant is located north of the boiler house on approximately three (3) acres of the five (5) acre parcel. An elevated pipe bridge, over railroad tracks, has been installed to allow pneumatic transfer of ash from the existing spray dryer ash silo to the aggregate plant. A new truck scale for weighing incoming shipments and outgoing product shipments will be located on the south side near the aggregate plant entrance. The main plant requires approximately 0.75 acres. This includes the area for:

- Personnel Parking
- A 48 Ft. x 72 Ft. two (2) story building housing most of the process equipment including:
    - Daybins and Silo for Admixtures
    - Weight Feeders
    - Solid Mixers
    - Extruder
    - Crushing and Screening Operations
    - Dust Collection System

- Six (6) sided steel, Curing Vessel Structure
- Modular office for office, lab and locker room
- Radial stacker storage of finished aggregate product
- Truck Scale

Site Plan

The General Site Location Plan for the UA Facility is shown on Drawing 001-GA-001. This drawing shows the location of the Universal Aggregate (UA) plant on the BPF property.
The UA plant occupies approximately five (5) acres north of the BPF baghouse between the BPF rail loop and the RF&P Rail Line. Access to the UA Plant is via the BPF entrance road on Route 665.

The detailed layout of the UA plant is shown on Drawing 001-GA-002. This drawing depicts the ingress and egress to the plant, the layout of the plant components and the position of the plant with respect to the BPF facility, the RF&P Rail Line and the wetland and Chesapeake Bay Preservation Areas to the north and northeast. The road crossing of the BPF rail loop lines has been improved to facilitate the UA Plant traffic.

Site Security

During both the construction and operation phases of the Universal Aggregates, LLC (UA) facility, the entire site area is enclosed by security fencing. The only access to the UA plant is through the Birchwood Power Facility (BPF) property. BPF provides twenty-four hour surveillance of the facility. All gates providing ingress or egress to the facility are either manned or locked to prohibit unauthorized access to the site.

Erosion and Sediment Control

The Erosion and Sediment (E&S) control measures are separated into Construction and Permanent plans. All vegetative and structural E&S control measures have been constructed and maintained to meet the standards and specifications of the Virginia Erosion and Sediment Control Handbook. A detailed E&S plan has been prepared in accordance with the King George County Site Plan Regulations and Erosion and Sediment Control Ordinance. The detailed site plan was approved by the King George County Planning commission on December 12, 2002.

Construction

The construction E&S program was implemented in two phases. The first phase includes measures put in place before the majority of the site is cleared or disturbed.

The second phase provides for enhancement and maintenance of the E&S controls through the end of construction, stabilization of the disturbed areas and completion of the final facility storm water management components. Typical components of the construction E&S plan are presented below:

Phase I.

- 1.1.1.1 Construction entrance installed at the limits of construction to a hard surface road.
- 1.1.1.2 Placement of perimeter controls, to include silt fence, sediment traps, diversion berms, tree protection/limits of work, stockpile areas identified with perimeter controls placed.
- 1.1.1.3 Clearing and grubbing of vegetation and topsoil.
- 1.1.1.4 Stockpiling.
- 1.1.1.5 Rough grading of site
- 1.1.1.6 Temporary seeding of stockpiles and denuded areas where work is not scheduled within seven (7) days.

Phase 2

- 1.1.1.7 Continued maintenance of E&S measures.
- 1.1.1.8 Continue with fine grading.
- 1.1.1.8.1 Placement of underground utilities (trenching and backfill work).
- 1.1.1.9 Surface prep and stabilizations work such as paving.
- 1.1.1.10 Placement of temporary E&S controls for inlets and piping, and outlet controls.
- 1.1.1.11 Final surface stabilization.
- 1.1.1.12 Clean-up/restoration work.

An integral part of the clean-up efforts is maintenance of the controls, removal of those controls where stabilization has been achieved, warranty work, installation of permanent measures and final removal of temporary measures.

The construction process was under the oversight of the County Inspectors in charge of E&S measures. A performance bond or other guarantee has been furnished to the County for all required improvements to insure compliance with the plan as approved. The bond will not be released until the project has been completed and site has been determined as stabilized by final inspection.

Chesapeake Bay Act Compliance and Storm water Management

This project will be completed in accordance with the Virginia Storm Water Management Regulations and the Article 8, Chesapeake Bay Preservation Act (CBPA) Overlay District of the King George County Zoning Ordinance. In addition, the facility is subject to the Virginia Department of Environmental Quality (DEQ) General Virginia Pollutant Discharge Elimination System (VPDES) Permit regulations for Discharges of Storm Water Associated With Industrial Activity (9 VAC 25-151-10).

Best Management Practices consistent with King George County and the Commonwealth of Virginia requirements have been incorporated into the site plan. Where possible, non-structural measures such as vegetative buffers have been used. Structural measures were focused in areas where developed improvements have been built.

The plant was built outside the 100-foot vegetated buffer Resource Protection Area (RPA) that has been mapped adjacent to and landward of nontidal wetlands along a small tributary of Birchwood Run northeast of the property. Work in the RPA was limited to minor channelization or pipe work to achieve adequate outfall criteria.

Final construction plans detail the work as proposed. Construction of the facility only required disturbance of approximately 3-acres of grassland that had been previously disturbed during construction of the BPF. No trees were cut for the UA plant. BMPs are designed to address first flush flows defined as the first half inch of rainfall. For water runoff rate control, the design standard is to control the two (2) and ten (10)-year storms to pre-development runoff rates.

The entire project area drains toward the RPA and the railroad track surface drainage system, located north and northeast of the proposed project. Material stockpile areas are located in areas where drainage can be controlled through catch basins and vegetative buffer areas to filter out suspended solids. The overflow/discharge from these areas is processed over level spreaders to reduce the concentration of flow and associated velocities before entering the RPA areas.

Use of catch basin structures facilitates the collection of the aggregate product, which tends to be a more uniform graded material consistent with a coarse grained sand material. The drainage area flowing from this site is relatively small.

Dust Control During Construction and Operation

There was minimal dust generation during construction and operation of the plant.

The plant occupies approximately three (3) acres of land immediately north of the site rail loop and boiler house. This area of the site had been previously disturbed during construction of the BPF. This land area is almost flat and vegetated with various grasses.

Very little earthwork was required to construct the plant, thereby minimizing dust generation. As necessary, dust control was enhanced during construction by watering of the construction area with either a water truck or manually with a hose.

During operation dust control is accomplished by a variety of methods. The spray dryer ash from the BPF is conveyed pneumatically in completely enclosed systems to various size storage bin hoppers. Each bin is equipped with a fabric filter that allows collected material to discharge back to the bin hopper. Additional fabric filters are provided at other material transfer points in the process. Emissions from the curing vessel were initially controlled by a venturi wet scrubber and cyclone. (This wet scrubber has been replaced by four fabric filter bin vents at the curing vessel inlet, and the addition of a fabric filter baghouse at the curing vessel discharge). Emissions from the crushing and screening operation are controlled by a separate fabric filter baghouse.

A surge bin with fabric filter bin vent was added to the recirculation circuit.

The final aggregate product is stored in stockpiles on an asphalt storage pad. The aggregate is loaded onto trucks by a front-end loader or possibly into a hopper/conveyor system for loading rail cars. Fugitive dust emission from the aggregate is minimal due to the high moisture and low silt fraction content of the aggregate. A water spray bar at the end of the stockpile conveyor is also used, as necessary, to control emissions. Additional water may be applied to the storage pad and aggregate if conditions warrant.

Electrical Distribution

Electrical distribution to the new Aggregate Plant is via the utility company (Dominion Virginia Power) furnished and installed 35KV/480V 2000KVA transformer located outside the process building.

The primary (35KV) feeder to this 2000KVA transformer was furnished and installed by the utility company (Dominion Virginia Power) from a utility owned 35KV source located within the Birchwood Power Facility via an overhead (pole line) system.

The secondary service lateral (480VAC) from the transformer to a 480VAC low voltage switchgear line-up has been installed via an embedded and exposed conduit system.

The 480VAC has further been distributed throughout the Aggregate Plant via power distribution panels, motor control centers, separately mounted starters and the like.

Level I Control System Overview

A Programmable Logic Controller (PLC) and a Multiple Feeder Controller perform plant process and supervisory control.

The PLC enclosure is located in the Electronic Room on the Operating Floor of the Aggregate Plant. The enclosure houses the PLC processor, I/O Racks, power supplies, fuses and terminal blocks to accommodate field wiring from field instruments, valves, motor starters, and operator panels. The PLC performs digital and analog control through programmed algorithms. The PLC communicates with an Operator Interface Panel and the Multiple Feeder Controller via fieldbus and hardwired I/O. The Operator Interface Terminal (OIT) is located in its own enclosure in a pulpit on the Operating Floor. The OIT provides system monitoring, alarm and control capabilities through a touchscreen display.

The Multiple Feeder Controller is located in the Electronic Room on the Operating Floor of the Aggregate Plant. The Feeder Controller enclosure houses the Feeder Processor, I/O Racks, power supplies, fusing, terminal blocks, power switches and terminal blocks for field wiring. The Feeder Controller supplies gravimetric and volumetric control for up to eight (8) systems for continuous batch dump operation. The Controller communicates with a dedicated touchscreen remotely mounted for operator interfacing for feeder levels, alarms, metering, motor operation and real time feed rates. Also, a remote printer is provided for reporting and logging.

The following are Level I controlled systems:

Existing Spray Dryer Ash (SDA) Silo F-110

SDA Day Bin F-120

Screw Conveyor L-120A

Screw Conveyor L-120B

SDA Weigh Feeder K-120A

SDA Weigh Feeder K-120B

Additive No. 1 Silo F-210

Screw Conveyor L-210

Additive No. 1 Weigh Feeder K-210

Additive No. 1 Pulverizer P-210

Recycle Daybin F-250

Screw Conveyor L-250B

Recycle Weigh Feeder K-250

Additive No. 2 Heated Storage Tank F-220

Additive No. 2 Feed System

Screw Conveyor L-310A

Screw Conveyor L-320

Pug Mill PM-310

Vacuum Pug Sealer PS-310

Extruder E-310

Aggregate Cutter AC-310

Reversing Belt Conveyor L-310B

Tumbler T-320

Belt Conveyor L-410A

Curing Vessel C410

Wet Scrubber B-420

Reversing Belt Conveyor L-410F

Belt Conveyor L-510A

Primary Screen G-510A

Horizontal Impactor HI-510

Secondary Screen G-510B

Belt Conveyor L-510C

Belt Conveyor L-510D

Belt Conveyor L-130

Bucket Elevator BE-130

Classifier Baghouse B-520

Screw Conveyor L-250A

Bucket Elevator BE-250

Screw Conveyor L-250C

Utility Water

Facility Description (Cont.)

The Process Building

The Process Building is a three (3) story, three (3) bay 79' by four (4) bay 72' structure which houses the Pug Mill, Pug Sealer, Extruder, Tumbler, Classifier, Ash Storage, Pulverizer, Horizontal Impactor, Additive Silos, Belt, Screw and Bucket Conveyors, Additive Feeders, Hydraulic System, Air Compressor, and Baghouse along with all their auxiliary components. The Process Building also has its own electrical equipment room and an air conditioned space for a PLC processor.

The Curing Vessel Structure

The Curing Vessel Structure is a six (6) sided steel, building structure with roof, 96'-6" high.

This structure houses the Curing Vessel, Wet Scrubber, Distribution Hopper, Conveyor, along with all their auxiliary components.

The Curing Vessel structure also contains connecting conveyors to the Main Building.

Site Water, Wastewater and Waste Management Plan

This plan provides for the management of the site water, wastewater and waste for the UA plant in accordance with applicable state and local regulations and good industrial site management practices.

Waste Management

The UA plant generates very little solid and no process waste. The process is set up so that all off-specification or potential process waste materials including baghouse and bin vent filter particulates are re-circulated back into the process. Therefore, there is no production of process waste materials. The plant generates some solid waste from the plant office and from normal and routine equipment operation and maintenance. UA contracts with a commercial waste hauler to supply a one (1) or three (3) cubic yard container for waste collection and regular pickup and offsite disposal.

Facility Description (Cont.)

No hazardous waste is generated at the site.

The facility has one-500 gallon aboveground storage tank for storage of diesel fuel for the front-end loader. The tank is enclosed within a leak containment vessel.

Site Water, Wastewater and Waste Management Plan(Cont.)

Potable Water

A Class IIIB Private Well supplies potable water for the plant. The well was designed and constructed in accordance with the Virginia Department of Health (VDH) Private Well Regulations 12 VAC 5-630.

It is estimated that there are an average of nine (9) employees working at the plant per day. Potable water is only used for sanitary purposes. Bottled drinking water is supplied separately. There are two restrooms, a small laboratory, a wash sink and an emergency shower at the plant. Consumptive water use is conservatively estimated to be 20 gallons per day (gpd) per employee for a total daily usage of 180 gpd. The plant is exempt from the Virginia Water Works Regulations 12 VAC 5-590 as there are only nine (9) employees per day. The well has been completed in the upper part of the Patuxent Formation or Potomac Aquifer that underlies the site at a depth of approximately 300 to 350 feet. The well was designed and installed in accordance with the American Water Works Association Standard for Water Wells AWWA A100-97. The well is equipped with a pitless adapter and a ¾ or 1 horsepower submersible well pump. Flow from the well is piped to a pressure tank located in the plant.

Following completion and development of the well the system was disinfected. Samples were collected and analyzed for coliform bacteria. In addition, samples were collected and analyzed for the drinking water constituents listed in 12 VAC 5-590. In the event the well water is unsuitable for drinking due to aesthetic reasons, bottled water will be used for drinking purposes.

There are no adverse impacts to offsite private wells due to the distance from the proposed plant well to the nearest private well and the low water withdrawal.

Process Water

Process water is obtained from the BPF and is 100 percent consumed or recycled in the plant processes. Approximately 40 to 60 gallons per minute is required for makeup process water. Most of this water ends up in the final aggregate product.

Sanitary Wastewater

Universal Aggregates, LLC (UA) disposes of sanitary wastewater onsite in accordance with the Virginia Department of Health (VDH) Sewage Handling and Disposal Regulations 12 VAC 5-610. The construction and operation of the Universal Aggregates (UA) plant requires amending the existing Birchwood Power Facility (BPF) King George Health Department Permit (WS-93-155) and modifying the construction of the effluent piping system to the drainfield. Amendment of the BPF permit and modification of the system is required for the following reasons:

- The UA plant is constructed on the reserve drainfield area for the BPF. Therefore, a new reserve area was located, characterized and approved by the Health Department.

- The UA sewage system includes a 1,000-gallon septic tank and 1,000-gallon sewage pump station. Effluent from the tank is pumped into the existing BPF wastewater disposal system.

As presented below the existing BPF drainfield has significant excess capacity and can easily accommodate the expected UA sanitary effluent. A new reserve area can be established at the drainfield permitted and constructed for the effluent for the construction trailers and workers that were onsite during construction of the BPF.

The following presents a brief overview of the existing BPF sewage disposal system and the expected sewage flows from the UA plant.

Birchwood Power Facility Sanitary Wastewater System

System Design Parameters		
System	-	Type III Enhanced Flow Distribution System
Soil Texture Class	-	Type II
Percolation Rate	-	45 minutes/inch
Design Capacity	-	3000 gallons per day based on 3 shifts of 25 employees per shift and 40 gallons per day per employee shift
Trench Bottom Area	-	6,870 square feet based on 229 sq. ft./100 gallons
Enhanced Flow Design	-	**Two Gorman Rupp Sewage Lift Station Pumps rated at 166 gallons per minute with 34-ft. total dynamic head.**
Percolation Lines	-	24 lines, 100 feet long
Installation Depth	-	48 inches
Trench Width	-	3 feet
Trench Spacing	-	9 feet

Septic Tank Effluent

The sewage pumps are constructed in parallel above a 6-ft. diameter, 12 ft. deep wet well with high and low water level controls and alarms. A transducer provides water level data in the wet well. Each pump is equipped with an hour meter. The Birchwood Power Plant began commercial operation in November 1996. According to plant records the sewage pumps were tested on August 8, 1996. It is assumed that the septic and drainfield systems were actively used starting on the August 8, 1996 test date.

As mentioned above the pumps have a rated capacity of 166 gpm. A short-term test was run on March 18, 2002. The test results indicated a pump rate of 148 gpm over the first two minutes of the test. The pump rate decreased to 139 gpm over the entire 3.5 minutes of the test as the water level in the wet well dropped.

Numerous readings of the hour meters on the sewage pumps have been collected over the two months. The total effluent volume and average daily pumping rate for different pump rates over the time period from March 5 to May 10, 2002 are shown on Table 1 below.

As mentioned above the sewage system was conservatively designed for 3000 gpd. The design capacity was based on 75 employees with 25 people working three shifts per day and an average sewage flow of 40 gallons per employee shift. The Virginia Department of Health (VDH) 12 VAC 5-610 recommends a design sewage flow of 15 to 35 gallons per employee per 8-hour shift for factories and office buildings. The regulations also recommend a safety factor of 1.4 for commercial mass drainfields.

Currently BPF employs 58 people working various shifts and shift durations. Reducing the various shifts to 8-hour shift equivalents indicates that 41 employees work the day shift Monday through Friday, 7.5 people work the combined evening and night shift and 7.5 people work the two shifts on weekends. Holidays, vacations and other time off are not accounted for. Averaging out the work hours to 8 hours over the entire week indicates there are an average of 39 8-hour shifts per day.

As shown in Table 1 the average daily sewage flow per employee per 8-hour shift varies from 16 to 18 gallons. The sewage flow data are at the low end of the VDH design flow criteria of 15 to 35 gallons per day per 8-hour employee shift**.**

Table 1 Sewage Flow Data and Estimates

Pumping Period	Pump Rate (gallons per minute)	Pumping Time (Hours)	Total Volume Pumped (gallons)	Average Daily Pump Rate (gallons per day)	Percent Design Capacity	Average Flow (gallons) per employee per 8-hour shift
3/5/02 – 5/10/02	166	4.6	45,816	694	23	18
	150	4.6	41,400	627	21	16
	140	4.6	38,630	585	20	15

Site Water, Wastewater and Waste Management Plan(Cont.)

Assuming a sewage flow of 20 gallons per employee shift yields a daily sewage flow of 180 gallons per day. Adding this flow to the range of flow estimates for Birchwood indicates that the total combined flow would range from 23 to 27 percent of the design capacity. At these flow rates the Birchwood system can easily accommodate the addition of 180 gallons per day from the Universal plant. To ensure the system is not being overused, sewage flows from the BPF and UA will be monitored on a regular basis.

The UA sewage system includes a 1,000-gallon septic tank and a sewage pump station. The effluent is pumped to the headworks of the BPF system upstream of the sewage flow splitter. Design details of the system are currently being developed and will be included in the Health Department Permit Amendment application.

III. New Birchwood Reserve Area

As noted above a separate septic tank and drainfield system was permitted (permit # S-93-215) for the construction trailers during construction of the BPF. This system was operated from mid-1994 until late 1996. The system was designed, permitted and constructed to handle 900 gpd. This system is located in an upland area northwest of the plant. Additional site characterization work is currently being performed to document that this area meets all the VDH criteria.

Storm Water

As previously noted the facility is subject to the Virginia Department of Environmental Quality (DEQ) General Virginia Pollutant Discharge Elimination System (VPDES) Permit regulations for Discharges of Storm Water Associated With Industrial Activity (9 VAC 25-151-10). The Standard Industrial Code (SIC) for the UA plant is 3295 Stone, Clay, Glass, and Concrete Manufactured Products. UA obtain a VPDES permit for the plant that specifies effluent limitations; maintenance, monitoring and reporting requirements; and preparation of a stormwater pollution prevention plan.

Drainage

This drainage project consists of approximately 71,154 Sq.Ft. of impervious area on a site of 3.87 acres. This impervious area includes an entrance road that crosses the existing railroad tracks in an access easement. BMP measures are required for this project to meet the Chesapeake Bay Watershed Pollutant Removal Standards. This site must meet a removal efficiency of 81.8%.

According to the Virginia Stormwater Management Handbook, the use of an infiltration basin will achieve a pollutant removal rate of 65% if the volume is sized to capture and treat the first 1" of rainfall runoff from the site's impervious area. Using this to calculate the Water Quality Volume (WQV), the BMP measure needs to capture 5,930 cubic feet of runoff. This measure also includes the use of a sediment removal forbay which will store the first ¼" of rainfall runoff. The runoff from the proposed structures and paved areas is to be captured in the proposed sediment removal forbay, and then is conveyed by either a pipe subdrain or sheet flow to the proposed infiltration pond.

The sediment removal forbay is a trench 5' wide and 3' deep containing VDOT#5 stone and an underdrain system. The forbay also has a layer of filter fabric at a depth of 12". This sediment removal forbay has a volume of approximately 1,480 cubic feet, storing the first ¼" of stormwater runoff from the impervious surface. The infiltration pond has a bottom area of 8,000 Sq.Ft. at Elevation 88.00, and a side slope of 2:1. This pond stores the first inch of stormwater runoff from impervious surfaces in 0.80 feet of depth. This volume of water infiltrates into the soils over a period of twelve (12) hours. This drawdown time was calculated using an infiltration rate of seventy-five (75) minutes per inch, which was determined by test pit and soil borings completed by the engineer.

2.3 Process Flow Diagram

Figure 1 is a process flow diagram of the manufactured aggregate facility. There are four major processing steps consisting of mixing, extrusion, curing, and aggregate product preparation. The mixing step is conducted by mixing together SDA (from SDA Daybin F-120), water (from Process Water Tank WT-710), and if desired an additive (from additive tank) with recycle material (from Recycle Daybin F-250). Mixing is done in a pugmill (PM-310) and a pug sealer (PS-310) where the mix components are thoroughly blended together to produce a plastic material with the consistency of damp dirt. The extrusion step is conducted by forcing the mixed materials through a die in an extruder (E-310) to produce “green” extrudates. The curing step is conducted by hardening the green extrudates through a curing vessel (C-410) where the extrudates are held for a time under moist warm conditions. The aggregate product preparation is conducted by crushing and screening the cured materials to produce properly sized crushed aggregate.

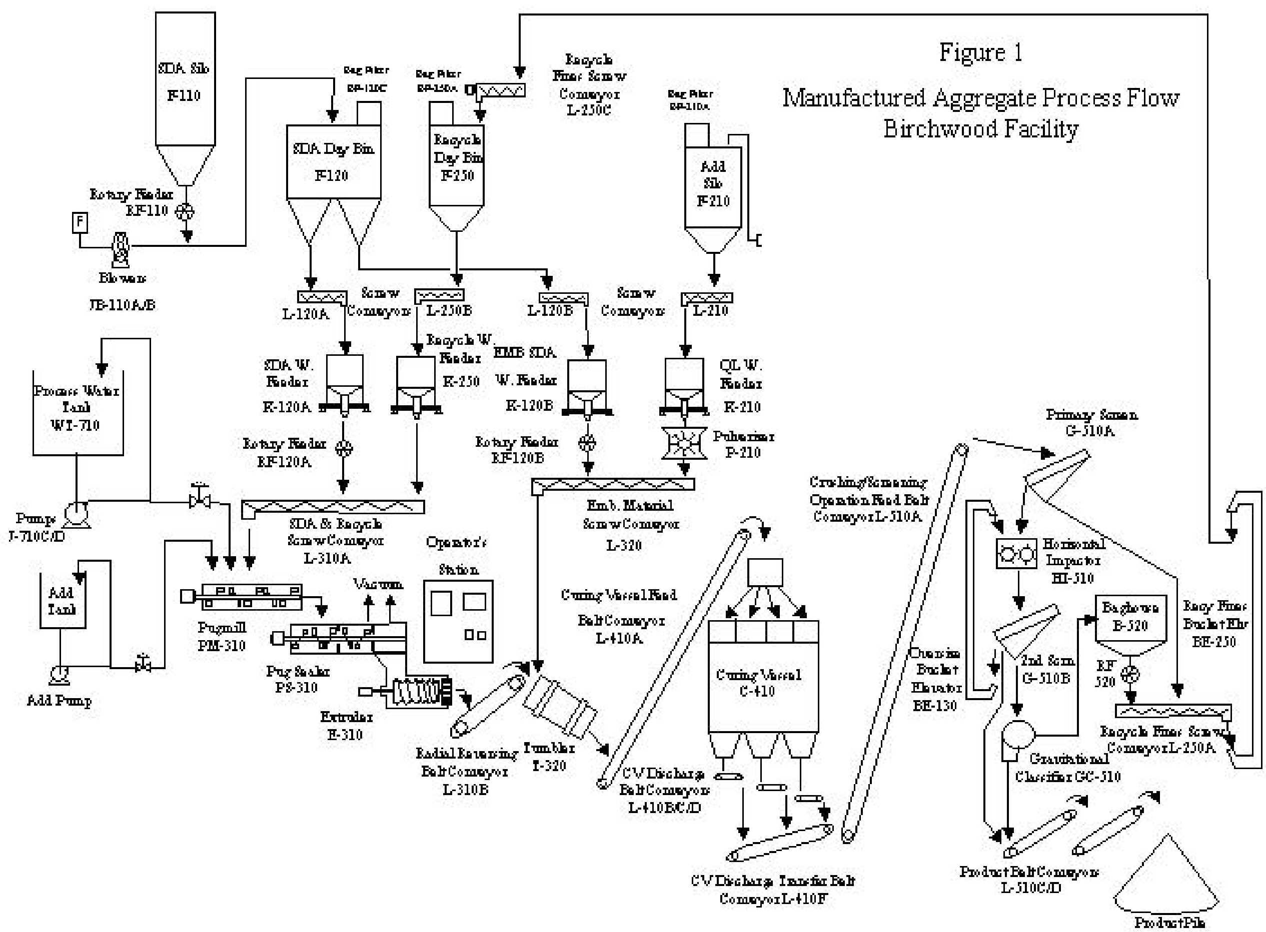


Figure 1

Manufactured Aggregate Process Flow
Birchwood Facility

Just prior to the curing step the green extrudates are mixed with embedding material in a tumbler (T-320). Embedding material is a mixture of SDA (from SDA Daybin F-120) and an additive (from Additive Silo F-210). The embedding material keeps the damp green extrudates separated so they do not stick or grow together in the curing vessel. It also supplies heat for cure hardening of the green extrudates in the curing vessel.

After curing, the fine embedding material is separated from the hard extrudates in a primary screen (G-510A). The recovered extrudates is crushed in a horizontal impactor (BE-130) and screened in a secondary screen (G-510B) to produce sized aggregates for aggregate product pile. Fines from the crushing and screening operations are collected in baghouse B-520 and recycled along with the recovered embedding material (from Primary Screen G-510A) back to Recycle Daybin (F-210) for use as a mix component.

3.0 UPDATE OF THE PUBLIC DESIGN REPORT

3.1 Design and Equipment Changes

During startup, equipment, feed and process controls, ash quality, mix design and process monitoring were modified to improve continuous plant operation and product quality was evaluated. These items and the associated benefits from the modifications are listed as follows:

<u>Pneumatic Ash Delivery System</u>

A pressure, pneumatic ash delivery system transfers the spray dryer ash (SDA) from the power station storage silo (F – 110), to Universal Aggregate's process building. Within UA's process building a receiving silo (daybin F – 120) acts in surge capacity prior to mechanical screw feed to the gravimetric weigh feeders. The original bin ventilation, bag filter on daybin (F – 120) was found to be inadequate in design capacity. New bin filter ventilation of improved capacity was retrofitted to daybin (F – 120) to aid in controlled ash delivery.

<u>Magnets and Strainers</u>

Tubular magnets were added between the discharge point of the power station's silo chute, and Universal Aggregates' transfer point to the rotary valve. Tramp metals from the power station's air pre-heater damaged both the rotary valve and the drive mechanism on several occasions. Mechanical damaged was also incurred on several occasions as tramp metals within the SDA feed were discharged from the K – 120 A gravimetric weigh feeder. The magnets are inspected regularly, and manually cleaned of any magnetically collected debris. In addition, a "cage–type strainer" was designed and installed at the discharge point of the pneumatic ash delivery line into Universal Aggregates' SDA daybin (F – 120). This "strainer" captures non–magnetic debris that passes from the power station ash delivery system, and into Universal Aggregates' process. The strainer is inspected regularly, and manually cleaned. Due to the regularity of tramp metal transfer from the power station into the SDA, Birchwood plant maintenance purchased and installed two "in – line" tubular magnets to aid in elimination of tramp metal transfer to Universal Aggregates process within the SDA.

<u>Mechanical Screw Feeders</u>

Screw feeder (L – 120A) mechanically transfers SDA from the daybin (F – 120), into the gravimetric weigh feeder (F – 120A). Additional auger segments were added, and the cover shroud tolerance tightened in an attempt to control the free–flow flushing of ash into the weigh feeder. Operational control parameters were established for proper gate valve operation, synchronized with ash delivery to assist in controlled ash delivery.

Gravimetric Weigh Feeders

Four gravimetric, loss–in–weight feeders control mix designs into the pugmill mixing and extrusion circuit, and in the embedding materials circuit. In the three feeders handling ash products (K – 120 A, K – 120 B, and K – 250), the original screw–type discharge components were required to be modified (upgraded) to rotary valve–type discharge units for positive, ultimate control in ash delivery. The originally equipped screw feed discharge units proved incapable of controlling the very fine grained, air laden SDA.

Pugmill

Modifications included dam and bridge installation, better water injection and ash spray systems, knife position change and shaft speed change to improve water dispersion, and ash /water contact during mixing. These modifications made the wetted ash denser at relatively reduced moisture contents and more acceptable for extrusion. Pugmill capacity was found to be unsatisfactory for total design integration. A new double–shaft pugmill was purchased and retrofitted into the system in February, 2007. The new pugmill provides approximately twice the volume capacity of the original pugmill. In addition, the new double–shaft pugmill will be retrofitted with a variable frequency drive for adjustable speed control.

Pugsealer

Modifications included dam installation and knife position change to further increase water to ash contact. It was also theorized that the conventional volume reduction auger design of 2.5:1 was too severe for the fine–grained SDA. An experimental auger was designed at 1.5:1. The auger was fabricated to fit the existing pugsealer, liner and shell design as a “proof of concept” design improvement to promote axial flow through the device. The shell liners were also modified from the original design to promote improved axial flow, and prevent plugging. Particle shear is important for water distribution upon the fine -grained SDA. Shear plates were designed to improve the shear mixing capabilities of the pugsealer, improve axial flow, and improve vacuum efficiency. A variable frequency drive and motor upgrade was also added to improve shear mixing, and vacuum efficiency. Modification to the sealing auger interface distance with respect to the sealing shear plate also contributed to improve deficiencies.

Extruder

Modifications included installation of a porcelain enameled auger, refinement of the liner and die geometry, and installation of single wing gap point auger to improve extrusion capacity and availability.

Curing Vessel

Upon the initial integration of the curing vessel (CV), improper mass flow was evident after several weeks of operation. Visual observations indicated an interruption in balanced flow of the Southwest portion of the CV.

Flow control and plugging was evident at the inlet to the CV loading and distribution pantlegs. This plugging was responsible for much of the interruption in the balance for equal distribution into the CV loading cans.

Equal distribution of product into the CV is important for mass flow control. The commingled aggregate/embedding blend is required to be distributed equally into the CV through the four distribution pantlegs, and into the four charging "cans" located in the upper elevation of the CV. Loading into each of the four cans is automated through radar level sensing equipment. In addition, sonar level sensing equipment was also employed.

In the original design, equal mass flow distribution into the four pantlegs was performed (inadequately) through a passive, equally divided distribution box, or hopper, located at the L – 410A headgate.

It was anticipated that the aggregate/embedding blend would fill each of the four pantlegs, with concurrent flow control into each of the four CV cans. On the roof of each of the Four CV cans, a gate valve was expected to open and gently drop the products over a distribution cone into each of the four CV cans.

Bridging of flow was apparent in each of the four distribution pantlegs. The flow cones in each of the four cans were removed due to suspected flow interruption. The gate valves were maintained in an open position to prevent bridging, and employ continuous, uninterrupted flow. The result was bridging and pluggage due to build–up upon impact points. A mechanical rotary distribution chute was then installed at the L – 410A headgate. This rotary chute could be coordinated to the level indicators in the four CV cans, and also timed for positive flow and level control.

Belt scales were also added to confirm CV discharge rates and balance flow. Belt scales also confirm final product to the stockpile.

A "recirculation" hopper and vibrating feeder were added to the CV recirculation circuit. The original design, although "closed loop", did not adequately control the return flow back onto the L – 410A conveyor; fugitive dust and flow interruptions frequently resulted. The recirculation of the CV is important for the proper flow control and curing during periods of idle or interrupted aggregate production.

Feed and Process Controls

Modifications included ash weight feeder, water injection system, and PLC and associated instrumentation.   As a result, stable ash feed can be maintained with accurate water addition to produce mixed products for extrusion.

Ash Quality

Assistance was provided to Birchwood Power Plant to implement a spray dryer modification program. The emphasis to optimize lime utilization in their spray dryer, and reduce the resultant hydrated lime content in the SDA. Lower hydrated lime content can reduce stickiness of wetted ash and make it acceptable for extrusion. A program was implemented to monitor carbon content and hydrated lime content in the feed ash and correlate the ash quality with process operating conditions.

Mix Design

Several admixtures were evaluated to improve mixing and extrusion. An admixture was identified and used to improve structural integrity of green extrudate at reduced moisture content during extrusion.

Process Monitoring

Monitoring was implemented to correlate readouts of pugmill and pugsealer amperage, and extruder speed to equipment performance. Adjustments of water and admixture addition in mix can be readily made to improve extrusion operation.

Product Qualities

A quality assurance and control program was implemented for monitoring aggregate products qualities, starting December 2004. Lightweight aggregates with proper size gradation and bulk densities were produced   Extruded products produced from the commercial extrusion process were cured in a bench-scale curing vessel, and then crushed and screened to proper size gradation for production of concrete masonry units (CMU) at the National Concrete Masonry Association (NCMA).   The CMU produced met the applicable ASTM quality requirements for compressive strength, water absorption, unit weight (or bulk density) and drying shrinkage.
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3.2 Updated Equipment List

Universal Aggregates
DE-FC26-02NT41421

Item #		Property Revised Equipment List			Date	# of Units
79	A	Pug Mill Platform	2	PJD	12/31/03	1
117	A	Pug Mill Platform	2	PJD	02/28/04	1
3	A	Office Trailer down payment	3	UA	06/25/03	1
47	A	Office Trailer 2nd payment	3	UA	09/16/03	1
4	A	Chevrolet truck	4	UA	06/25/03	1
34	A	Less retention	18	PJD	08/31/03	
26	A	Structural Steel	19	PJD	08/31/03	1
31	A	Oil Flooder Compressor	21	PJD	08/31/03	1
57	A	Oil Flooder Compressor	21	PJD	10/31/03	1
33	A	Recovery System	23	PJD	08/31/03	1
36	A	Pug Mill Platforms	24	PJD	09/30/03	1
46	A	Twenty foot Containers	29	UA	09/15/03	2
51	A	Hoists	32	UA	10/23/03	2
62	A	Ventilation System	35	PJD	10/31/03	1
73	A	Ventilation System	35	PJD	11/30/03	1
63	A	Desk, Chairs & crendenza	36	UA	11/30/03	5
71	A	Pipe & Insulation	40	PJD	11/30/03	
81	A	Pipe & Insulation	40	PJD	12/31/03	
102	A	Pipe & Insulation	40	PJD	01/31/04	
119	A	Pipe & Insulation	40	PJD	02/28/04	
130	A	Pipe & Insulation	40	PJD	03/31/04	
187	A	Pipe & Insulation	40	UA	09/30/04	1
194	A	Pipe & Insulation	40	UA	09/30/04	1
72	A	Overhead Doors	41	PJD	11/30/03	3
74	A	Doors, Frame & Hardware	42	PJD	11/30/03	16
120	A	Doors, Frame & Hardware	42	PJD	02/28/04	1
131	A	Doors, Frame & Hardware	42	PJD	03/31/04	1
210	A	Door frames	42	UA	07/01/05	Various
244	A	exterior Plant Door	42	UA	07/01/06	1
75	A	Small Tools	43	PJD	12/30/03	
114	A	Small Tools	43	PJD	02/28/04	Various
129	A	Small Tools	43	PJD	03/31/04	
84	A	Submerge Pump	46	UA	12/31/03	1
85	A	Electrical hookup	47	UA	12/31/03	1
140	A	Electrical hookup	47	UA	03/31/04	

87	A	Lab Equipment	48	UA	12/31/03		
123	A	Lab Equipment	48	UA	02/28/04		
124	A	Lab Equipment	48	UA	02/28/04		
183	A	Lab Equipment	48	UA	07/31/04		1
89	A	Moisture Analyzer	50	UA	12/31/03		1
90	A	Electricial Supplies	51	UA	12/31/03		
98	A	Sears small tools	58	UA	12/31/03	Various	
99	A	Trailer	59	UA	12/31/03		1
100	A	Crane	60	UA	12/31/03		1
121	A	Crane – transportation	60	UA	02/28/04		1
101	A	Small tools	61	UA	12/31/03	Various	
106	A	Virginia Tax on property	64	UA	01/31/04		1
107	A	Storage Container-CSE	65	UA	01/31/04		1
108	A	Crane	66	UA	01/31/04		1
167	A	Crane transportatopn	66	UA	05/31/04		1
109	A	Plant sign	67	UA	01/31/04		2
138	A	Plant sign	67	UA	03/31/04		2
110	A	Various Plant Supplies	68	UA	01/31/04		
112	A	Oven	70	UA	01/31/04		1
113	A	3 HP Motor	71	UA	01/31/04		1
126	A	Moisture Analyzer Printer	72	UA	02/28/04		1
127	A	Welding Equipment	73	UA	02/28/04		1
128	A	Two way radios	74	UA	02/28/04		4
137	A	Modems-56k	77	UA	03/31/04		3
141	A	Versa Loader	78	UA	03/31/04		1
161	A	Plant Engr-start	83	UA	05/31/04		1
163	A	Plant Engr-start	83	UA	05/31/04		1
164	A	Plant Engr-start	83	UA	05/31/04		1
174	A	Plant Engr-start	83	UA	06/30/04		1
184	A	Plant Engr-start	83	UA	07/31/04		1
190	A	Plant Engr-start	83	UA	09/30/04		1
198	A	Plant Engr-start-Casey.	83	PJD	12/31/04		1
220	A	Plant modifications	83	UA	07/01/06		1
153	A	Trailer	84	UA	04/30/04		2
162	A	Office Trailer	84	UA	05/31/04		1
159	A	Storm Water Permit	89	UA	05/31/04		1
197	A	Downflo Collector-Donaldson	101	UA	11/30/04		1
201	A	Downflo Collector-Donaldson	101	UA	12/31/04		1
200	A	Office Trailer	102	UA	12/31/04		1
202	A	Office Trailer	102	UA	01/31/05		1
205	A	Mobile Office Trailer	102	UA	05/14/05		1
206	A	Platform & Ladder	103	UA	07/01/05		1

211	A	Misc Bldg	103	UA	07/01/05	Various
217	A	Furance	105	UA	07/01/05	1
221	A	Baghouses	106	UA	07/01/06	6
228	A	Motorola Radios	110	UA	07/01/06	12
234	A	Portable Vaccum System	113	UA	07/01/06	1
236	A	Safety Harness	115	UA	07/01/06	2
241	A	CAT Telescopic Handler	120	UA	07/01/06	1
243	A	Steam Transportation System	122	UA	07/01/06	1
247	A	Construction & Subcontractors	124	UA	07/01/06	1
52	A	Virginia Tax on various purchases		UA	10/23/03	
237	A	Welding Machine	116	UA	07/01/06	1
1	B	Building Permit	1	UA	02/06/03	1
64	B	Bobcat	37	UA	11/30/03	
65	B	Permit	38	UA	11/30/03	1
88	B	Sweeper Attachment-Bobcat	49	UA	12/31/03	1
149	B	Trailer	84	UA	04/30/04	1
154	B	Bobcat Bucket	85	UA	04/30/04	1
177	B	Paving-around the Curing Vessel	94	UA	06/30/04	1
245	B	Parking lot	94	UA	07/01/06	1
70	C	Pneumatic Transport System	39	PJD	11/30/03	1
83	C	Flange & Gasket	45	UA	12/31/03	2
193	C	RT Sampler	98	UA	09/30/04	1
196	C	700 metric feeder drive Assy	100	UA	11/30/04	1
212	C	Taper Bushed Reducer-Ash trf	104	UA	07/01/05	1
224	C	Pneumatic Air trf. Sys modification	104	UA	07/01/06	1
229	C	Metal Extractor	104	UA	07/01/06	1
7	D	Storage tank - 30% down payment	7	PJD	06/30/03	5
27	D	Storage tanks - 2nd payment	7	PJD	08/31/03	5
32	D	Heat exchanger, water & additive tanks	22	PJD	08/31/03	3
59	D	Heat exchanger, water & additive tanks	22	PJD	10/31/03	3
122	D	Flange & Gasket	45	UA	02/28/04	1
91	D	Tank & pressure switch	52	UA	12/31/03	1
92	D	Tank & pressure switch-transportation	52	UA	12/31/03	1
93	D	Storage Tank-Flint & Walling	53	UA	12/31/03	1
94	D	Valves & Meters	54	UA	12/31/03	20
143	D	Gate Cylinders	80	UA	03/31/04	7
144	D	Ultrasonic LVL Transmitter	81	UA	04/30/04	1
171	D	Leslie 35R Actuators	92	UA	06/30/04	2
223	D	Roots Blower-Day bin	107	UA	07/01/06	1
226	D	Additive Tank	109	UA	07/01/06	1
235	D	Tank	114	UA	07/01/06	1

215	E	Pugmill & Sealer modifications	2	UA	07/01/05	1
232	E	Pug Sealer modifications	2	UA	07/01/06	1
95	E	Shock absorbers for conveyor	55	UA	12/31/03	8
168	E	High speed Blender-Scott	91	UA	05/31/04	1
179	E	High speed Blender-Scott	91	UA	06/30/04	1
185	E	High speed Blender-Scott	91	UA	07/31/04	1
188	E	Grundfos Pump	96	UA	09/30/04	1
5	F	Telescopic Radial Stacker	5	UA	06/30/03	1
42	F	Telescopic Radial Stacker-shipping	5	UA	09/05/03	1
6	F	Conveyors -15% down payment	6	PJD	06/30/03	6
13	F	Conveyor -2nd payment	6	PJD	07/31/03	3
23	F	Conveyor -3rd payment	6	PJD	08/31/03	3
44	F	Shock absorbers for conveyor	6	UA	09/15/03	8
67	F	Conveyors	6	PJD	11/30/03	3
146	F	Conveyors -	6	UA	04/30/04	1
151	F	Conveyors	6	UA	04/30/04	1
152	F	Conveyors	6	UA	04/30/04	1
155	F	Conveyors	6	UA	05/31/04	1
170	F	Conveyors	6	UA	05/31/04	2
180	F	Conveyors	6	UA	06/30/04	1
189	F	Conveyors	6	UA	09/30/04	2
213	F	Conveyors-Eurodrive Gear red.	6	UA	07/01/05	1
216	F	Conveyors- Belts	6	UA	07/01/05	1
227	F	Conveyor impact Bars	6	UA	07/01/06	1
14	F	Bucket Elevator	12	PJD	07/31/03	2
135	F	Bucket Elevator-freight	12	UA	03/31/04	1
20	F	Rotary Valve	14	PJD	07/31/03	1
21	F	Aggregates Sampler System	15	PJD	07/31/03	1
24	F	Conveyor Belts	17	PJD	08/31/03	6
53	F	Conveyor Belts	17	PJD	10/31/03	6
77	F	Conveyor Belts	17	PJD	12/31/03	6
82	F	Conveyor Belts	17	PJD	12/31/03	1
116	F	Conveyor	17	PJD	02/28/04	
61	F	Sampler	34	PJD	10/31/03	1
96	F	Frame Assy (W-4000)	56	UA	12/31/03	1
150	F	Chute	85	UA	04/30/04	1
225	F	Electric Jack	108	UA	07/01/06	1
231	FF	Conveyor modifications	6	UA	07/01/06	1
38	G	Toshiba Drive Unit	25	PJD	09/30/03	1
58	G	Toshiba Drive Unit	25	PJD	10/31/03	1

104	G	Toshiba Drive Unit-start up	25	UA	01/31/04	1
39	G	Electronic Equipment - Casey Ind.	26	PJD	09/30/03	1
41	G	Operator Interface Station	27	UA	09/04/03	1
45	G	Electronic Instrumentation	28	UA	09/15/03	4
49	G	Pulpit (Oper. Station)	30	UA	10/23/03	1
50	G	Computer	31	UA	10/23/03	1
60	G	Control room pulpit	33	PJD	10/31/03	1
103	G	Preasure valves	62	UA	01/31/04	Various
105	G	Preasure switch-transport blower	63	UA	01/31/04	1
111	G	AC Controls-terminal block	69	UA	01/31/04	1
134	G	Turbine meter-Omega	75	UA	03/31/04	1
175	G	Turbine meter-Omega	75	UA	06/30/04	1
136	G	Loop Power Indicator	76	UA	03/31/04	1
142	G	Electronic Wall Station	79	UA	03/31/04	1
145	G	Gate logic panals	82	UA	04/30/04	4
147	G	Plant Engr-start	83	UA	04/30/04	1
148	G	Plant Engr-start	83	UA	04/30/04	1
158	G	Valves & Meters	88	UA	05/31/04	4
178	G	Storm Water -Hydro	89	UA	06/30/04	1
165	G	Toshiba drives- toshiba	90	UA	05/31/04	2
173	G	Toshiba drives- toshiba	90	UA	06/30/04	2
176	G	APS Smart Unit	93	UA	06/30/04	1
181	G	FVNR starter Unit	95	UA	06/30/04	1
192	G	Relief valve -f120	97	UA	09/30/04	1
195	G	Honeywell EZTrend	99	UA	11/30/04	1
238	G	Trend Recorder	117	UA	07/01/06	1
246	G	Control Panels	123	UA	07/01/06	1
2	H	Extruder down payment	2	UA	05/30/03	1
40	H	Extruder - 2nd & 3rd payment	2	UA	08/25/03	1
43	H	Extruder-4th payment	2	UA	09/15/03	1
48	H	Extruder Part	2	UA	09/30/03	1
139	H	Extruder Part	2	UA	03/31/04	
160	H	Extruder parts	2	UA	05/31/04	32
186	H	Extruder	2	UA	08/31/04	1
191	H	Extruer	2	UA	09/30/04	1
208	H	Extruder Liner	2	UA	07/01/05	1
219	H	Extruder modifications	2	UA	07/01/06	1
9	I	Tumbler Drum - 30% down payment	9	PJD	06/30/03	1
16	I	Tumbler Drum - 2nd payment	9	PJD	07/31/03	1

10	I	Wet scrubber - 20% down payment	10	PJD	06/30/03	2
17	I	Wet Scrubber - 2nd payment	10	PJD	07/31/03	2
37	I	Wet Scrubber - 3rd payment	10	PJD	09/30/03	1
55	I	Wet Scrubber – 4thpayment	10	PJD	10/31/03	1
25	I	Curing Vessel	18	PJD	08/31/03	1
35	I	Curing Vessel	18	PJD	09/30/03	1
54	I	Curing Vessel	18	PJD	10/31/03	1
68	I	Curing Vessel	18	PJD	11/30/03	1
78	I	Curing Vessel	18	PJD	12/31/03	1
132	I	Curing Vessel	18	PJD	03/31/04	1
204	I	Rotary Feeder System	18	UA	04/01/05	1
207	I	Rotary Feeder System	18	UA	07/01/05	1
218	I	Curing Vessel modifications	18	UA	07/01/06	1
222	I	Curing Vessel modifications	18	UA	07/01/06	1
29	I	Lime Pulverizer	20	PJD	08/31/03	1
230	I	Lime Pulverizer	111	UA	07/01/06	1
233	I	Sidewalker Moles	112	UA	07/01/06	3
239	I	Trumbler modifications	118	UA	07/01/06	1
22	J	Acrison Feeders	16	PJD	08/31/03	4
66	J	Acrison Feeders	16	PJD	11/30/03	4
76	J	Acrison Feeders	16	PJD	12/31/03	1
115	J	Acrison Feeders	16	PJD	02/28/04	1
125	J	Acrison Feeders	16	UA	02/28/04	4
209	J	Rotary Valve-Acrison	16	UA	07/01/05	2
214	J	BRG Pilot & Auger-Acrison	16	UA	07/01/05	1
80	J	Truck Scale	44	PJD	12/31/03	1
118	J	Truck Scale	44	PJD	02/28/04	1
182	J	Truck Scale	44	UA	07/31/04	1
156	J	Lime Chute	86	UA	05/31/04	1
157	J	Airlock feeder-smoot	87	UA	05/31/04	1
166	J	Airlock feeder-smoot	87	UA	05/31/04	2
199	J	Airlock feeder-smoot	87	UA	12/31/04	1
240	J	Recycle feeder modification	119	UA	07/01/06	1
97	K	Volvo Loader	57	UA	12/31/03	1
133	K	Volvo Loader	57	UA	03/31/04	1
169	K	Volvo Loader	57	UA	05/31/04	1
172	K	Volvo Loader	57	UA	06/30/04	1
203	K	Volvo Frontend Loader	57	UA	04/01/05	1
8	L	Crusher Screens - 50% down payment	8	PJD	06/30/03	3

15	L	Crusher Screens - 2nd payment	8	PJD	07/31/03	3
28	L	Crusher Screens - freight	8	PJD	08/31/03	1
11	L	Impactor - 25% down payment	11	PJD	06/30/03	1
12	L	Impactor - 30% down payment	11	PJD	06/30/03	1
19	L	Impactor - 3rd payment	11	PJD	07/31/03	1
56	L	Impactor - 30% down payment	11	PJD	10/31/03	1
69	L	Impactor Return	11	PJD	11/30/03	1
18	L	Air Classifier - 30% down payment	13	PJD	07/31/03	1
30	L	Air Classifier - 2nd payment	13	PJD	08/31/03	1
86	L	Sieve & Sieve Shaker	47	UA	12/31/03	
242	L	Crusher Hammers	121	UA	07/01/06	1

	UA Birchwood Equipment Categories
A	Plant Buildings (general)
B	Site (general)
C	Ash Transfer
D	Materials/Feedstock Storage
E	Mixing
F	Conveyors
G	Controls
H	Extrusion
I	Curing
J	Weights & Measures
K	Transportation
L	Crushing/Screening

4.0 DEMONSTRATION PROGRAM

Table 1 listed in Pages T-1, T-2 and T-3 summarizes the plant demonstration operations from April 2004 to December 2006. A more detailed operation history is provided in Appendix B. The demonstration program is divided into; 1) test plan, 2) operating procedures, 3) analyses of feedstocks, products and reagents, 4) data analysis methodology, 5) data summary, 6) operability and reliability for the following discussion.

4.1 Test Plans

The original mixing and extrusion equipment (pugmill, pugsealer and extruder) were of conventional design to process clay and shale materials for brick manufacturing and not to process spray dryer ash for aggregate production. The curing vessel was a new design for use in large-scale commercial application. Short-term tests were conducted to evaluate operating parameters on equipment performance. Test results were used to modify individual equipment and to optimize its performance in the integrated runs for aggregate production. Short-term tests were also conducted to evaluate ash qualities and the effect of mix formulation on extrusion performance. Long-term tests were conducted to integrate all equipment and process steps (mixing, extrusion, curing, crushing and screening) for aggregate production. Performance of the integration runs and material balance are included in the discussion of long-term tests.

4.1.1 Short-term Tests

The table below lists short-term tests and their objectives. Each short test is discussed next to the table.

SHORT TERM TESTS AND OBJECTIVES

Short-Term Test	Objectives
Equipment	
Pugmill	To evaluate the effects of dam and bridge installations in pugmill and water spray system on mixing and extrusion
Pugsealer	To evaluate the effects of pugsealer speed on pugsealer and extruder operations and on properties of green extrudates
Extruder	To evaluate the effects of die geometry, liner design, vacuum and additive addition on extruder performance
Curing Vessel	To evaluate the effects of operating throughput rate, rotary distribution chute, adjustable flow dampers and QA/QC program on curing vessel performance
Screen, Crusher and Air Classifier	To evaluate the effects of screen decks, rotor speed and clearance between breaker bar and plate, opening of dampers and choke gate on size gradation and bulk density of aggregate products
Ash Quality	To evaluate the effects of hydrated lime and carbon contents on mixing and extruder performance
Mix Design	To evaluate the effects of mix formulation (SDA, recycle, additive and water) on pugmill, pugsealer and extruder performance

(1) Equipment

Pugmill

A parametric test was conducted in June 2004 to evaluate the effects of the pugmill dam installation, water injection nozzle configuration and overall water addition on pugmill performance. Test results indicated that improved water and ash contact can enhance densification of wetted ash in the pugmill and benefit overall extrusion operation. Improved water and ash contact at a constant water addition can be achieved by installing a high dam near the pugmill outlet to increase retention time and by installing fine spray nozzles to reduce water droplet size. Increased water addition can also increase the densification of wetted ash in the pugmill. The parametric test results were used as a guideline to modify the pugmill and the water spray nozzle arrangement. Properties of wetted ash, collected at the pugmill outlet, were monitored after pugmill modifications in September 2004. Better ash densification with reduced moisture content was achieved by introducing a dam in the first third of the pugmill, and by increasing the dam height at the pugmill outlet. A “bridge”, or roof-dam located at midpoint helped to prevent ash segregation and improve the knife to ash contact. The installation of a high pressure water pump improved water pressure control and spray pattern. Mixing speed of pugmill was increased by sheave removal.

Pugsealer

Tests were conducted in November and December 2005 to evaluate the effects of pugsealer speed on pugsealer and extruder operations and on properties of green extrudates. Operation variables monitored included pugsealer amperage, vacuum of pugsealer and extruder. Extrudate properties determined included moisture contents, penetrometer reading, percent of deflection and number of cracks after 10 ft drop test.

Test results indicated that extruder vacuum can be increased with reduction of pugsealer speed to improve extrudate properties (i. e., penetrometer reading and deflection in drop test). Based on the test results, a variable frequency drive was installed in pugealer to adjust pugsealer speed and improve extrusion operation in May 2006.

Extruder

Several admixtures were evaluated as an extrusion aid to improve extrusion performance.

Several different designs of extruder die with 1”, 1.5” and 2” diameter opening were tested

A liner design was experimented with to determine the best available configuration to maintain extrusion performance.

Tests were conducted to evaluate the effect of extruder vacuum on penetrometer reading and structural integrity of green extrudates from extruder die.

The extruder was equipped with a variable speed drive. This feature was most advantageous when employed in conjunction with the variable frequency drive upgrade to the pugsealer. As a result, improved mixing, increased vacuum efficiency, and uniformity of flow was apparent. The improvement in the quality of extrudates was also evident when tested for penetration resistance, crack propagation and moisture content.

Curing Vessel

Prior to full integration, belt timing and belt speeds were confirmed for the loading and unloading circuit to the CV. Although the discharge rate was predictable, actual belt–scale weight data was lacking. Therefore, belt cut weight samples were procured to correlate belt speed and the relative balance between loading and unloading the CV in balanced control.

A quality control program was initiated to monitor aggregate quality prior to charging the CV. Temperature of the aggregate and embedding material blend is monitored for assurance of adequate embedding blend which is responsible for strength development of cured extrudates, and acts as a bond breaker between the extruded aggregates to prevent large conglomerates from forming, which would prevent even flow from happening within the CV. Moisture content of the commingled embedding material is indicative of the degree of exothermic reaction taking place upon the material. The resistance to penetration is measured at the extruder die and at the L- 410 A headgate. This penetrometer reading is directly related to internal cohesion and shear of the compacted extrudate. Penetration resistance upon extrusion is directly related to compaction and relative mix performance within the pugsealer and extruder. Penetration resistance upon CV loading (approx. 4.5 minutes after production) indicates preliminary exothermic activity upon the extrudate. Visual observations confirm radar and sonar level indication in charging the CV cans.
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Velocity profile testing within the CV was employed to determine the required minimum operating throughput rate to assure positive uninterrupted flow within the CV and prevent the formation of conglomerate masses. The design engineer was consulted on several occasions, visited the site, and recommended specific testing procedures and the resultant flow rate parameters. A new rotary distribution chute was installed for better curing vessel charge in May 2005. A new CV recirculation system was installed for improvement of CV operation in May 2006. Adjustable flow dampers were installed and mounted to the base of internal pintle of the CV to achieve uniform velocity in each of four cans in October 2006.

A labor intensive cleaning was conducted within the CV to assure that no blockage of flow was prevalent prior to the recharging of the CV in April 2005. This cleaning program required proper safety training for confined space vessel entry. Operation employees also gained first hand knowledge of the internal workings and design of the CV, the importance of the QAQC program, and operational controls required to balance and maintain unimpeded material flow in the CV.

<u>Screen, Crusher And Air Classifier</u>

Tests were conducted to evaluate openings of screen decks in primary and secondary screens, rotor speed and clearance between breaker bars and plates in crushers and openings of primary and secondary dampers and choke gate in air classifier on size gradation and bulk density of aggregate products. Three and five decks with different openings were selected for use in primary and secondary screens. Rotor speed and clearance between the breaker bars and plates in crusher were adjusted to control product sizes. Opening in primary and secondary dampers and choke gate in air classifier were adjusted to control products fines (-100 mesh).

(2) Ash Quality

A program was initiated in June 2004 to monitor qualities of spray dryer ash and wetted ash collected at the pugmill, pugsealer and extruder outlets. Qualities of spray dryer ash monitored include moisture content, hydrated lime content and bulk density. Qualities of wetted ash monitored include moisture content, bulk density and temperature. Hydrated lime content in the SDA was identified as an important factor that influences extrusion performance. Spray dryer ash with hydrated lime content above 24% was difficult to extrude, due to increased stickiness of the wetted ash. Assistance was provided to the Birchwood Power Plant to implement a spray dryer modification program for lime optimization to reduce hydrated lime content in the SDA and improve ash quality in October 2004.

(3) Mix Design

Tests were conducted to evaluate the effect of mix formulation on mixing and extrusion performance and properties of green extrudates. Several admixtures and other components were evaluated to improve mixing and extrusion. An admixture was identified and used to improve structural integrity of green extrudates at reduced moisture content during extrusion.

4.1.2 Long-term Tests

Long-term tests were conducted to integrate mixing, extrusion, curing, crushing and screening for aggregate production. Inputs of mix components have direct effects on quantities of material processing in the long-term tests. For a reference, Table 2 in Pages T-4 and T-5 and Table 3 in Pages T-6 and T-7 show calculated operation conditions for three levels of extrudate moisture Contents (32%, 30% and 28%, dry basis) at various feedrates of mix components (SDA from K120A, recycle, water and additive) for aggregate production. In Table 2 with low throughput, feedrates of SDA from K120A range from 12,000 lb/hr, to 16,000 lb/hr and to 18,000 lb/hr. In Table 3 with high throughput, feedrates of SDA from 120A range from 20,000 lb/hr, to 25,000 lb/hr and to 30,000 lb/hr. Three levels of recycle feedrates are listed; 0% feedrate, 50% of SDA feedrate, feedrate for material balance. In addition, included in Tables 2 and 3 for comparison are feedrate of embedding material, production rate of recycle, charge and discharge rate of curing vessel and production rate of aggregates. Curing vessel charge is a blend of extrudates and embedding material. Curing vessel discharge is a blend of cured extrudates and embedding material. Embedding material is a blend of SDA and additive #1. Recycle is a blend of cured embedding material, some crushed fines and dusts collected from baghouses. In long-term tests, qualities of products generated from each process step were monitored to maintain adequate process control for aggregate production.

As shown in Table 2 and Table 3, mix formulation with different levels of extrudate moisture contents are related to quantities of embedding material, recycle production, curing vessel charge and discharge, and crushed aggregate production. If recycle production rate is higher than recycle consumption rate as a mix component (i. e., not a material balance run), recycle will fill up in recycle daybin (F-250). Curing vessel discharge and aggregate production must be stopped periodically to empty the recycle, which has accumulated in the recycle daybin. Extrusion runs will be conducted to empty the recycle daybin without curing vessel charge and aggregate production. A continuous long-term integration run for aggregate production must be conducted with material balance. In material balance runs, recycle consumed as a mix component must be equal to recycle production, as indicated in shaded numbers in Table 2 and Table 3. Ratios of recycle/SDA of 0.72 to 0.76 are generally required in material balance runs with equal recycle consumption and production as indicated in Table 2 and Table 3.

The plant achieved integrated operation with mixing, extrusion, curing, crushing and screening for aggregate production in December 2004 and continued into January, February and March of 2005 for a relative short time of up to ten hours and low SDA throughput of up to 12,000 lb/hr (about 30% capacity of weight feeder k-120A). The production rates were lower than designed capacity, mainly due to free flow problem of the aerated SDA at higher throughput, extruder operation problems, uneven distribution of curing vessel charge, difficulty of maintaining can levels in curing vessel discharge and other equipment related issues such as dust control and ash transfer. However, we demonstrated that the process does work by producing over 1,000 tons of manufactured lightweight aggregates from December 2004 to March 2005. The aggregates with proper size gradation and bulk density were produced, sold and used successfully by a Maryland masonry producer in production of concrete masonry units.

Modifications were made to increase SDA throughput and to improve extruder and curing vessel and other equipment operations from April to August 2005. Integration runs were made with SDA throughput up to 22,000 lb/hr and the plant produced about 1,500 tons of extruded products for aggregate production in September 2005. The front end of the plant (mixing/extrusion) operated at improved level of reliability with SDA throughput up to 29,000 lb/hr in October and November 2005. However, equipment and operational problems still limited long-term integrated runs and impeded plant capacity and availability for aggregate production. The management team was reorganized with emphasis on identifying and resolving problem areas of the plant for aggregate production in October 2005. The milestone of 24 hours continuous integrated operation as requested by DOE was achieved on December 12 and 13, 2005.

Modifications of pugsealer, extruder, curing vessel and other equipment continued with limited integration runs for aggregate production. About 700 tons, 965 tons and 627 tons of aggregates were produced in January, February and March 2006, respectively. Extensive repairs, modifications and installations of new equipment were conducted throughout the plant from April to most of July 2006.

Integration run was resumed on July 25, 2006. About 900 tons of aggregate were produced July 25 to July 31, 2006. About 3,000 tons of crushed aggregate was produced in the month of August 2006. Recycle material was used as a mix component on a continuous bases at 2,000, 4,000 and 6,000 lb/hr. Higher feedrates of recycle (e. g., 8,000 lb/hr) often caused a flushing (or free flow) problem of the recycle feeder (K250) and high moisture content in green extrudates. High moisture content of green extrudates can cause high water absorption in aggregate products. A discussion was held with the vendor of recycle feeder K250 to install a rotary airlock to prevent flushing as done in the K120A weight feeder. Insufficient mixing of SDA and recycle at high feedrate in the single-shaft pugmill was identified as the cause of high moisture content of green extrudates. Mild weather caused Birchwood Power plant to operate at lower loads in September than in August 2006. About 1,730 tons of aggregate was produced in September 2006. Outage by Birchwood Power plant prevented aggregate production from September 23 to November 24, 2006. Unseasonably mild weather caused the Birchwood Power plant to operate at reduced loads in December 2006. Consequently, the manufactured aggregate plant was sometimes operated at lower throughputs. In addition, the plant was shutdown on Christmas day. Aggregate production was 1,276 tons in December 2006. A total of 6,000 tons of aggregates was produced and stockpiled for shipment in August, September and December 2006.

Aggregate production for integrated operation improved in 2006. However, the plant availability for aggregate production is still limited by the amount of recycle, which needs to be incorporated as a mix component in pugmill during continuous operation. Recycle feedrate is also limited by recycle flushing (or free flow) at high throughput over 6,000 lb/hr. A double shaft pugmill was constructed in December 2006 and would be used to increase mixing intensity to process all generated recycle for full integration of aggregate production in early 2007. In addition, an airlock would be installed at the bottom of recycle feeder to reduce flushing problem and provide steady operation of recycle feed at high throughput in January 2007. Full integration for aggregate production with high recycle throughput would be accomplished in 2007.

4.2 Operating Procedures

(1) Manufacturing Process

The Universal Aggregates, LLC process converts flue gas desulfurization (FGD) scrubber by-product materials into manufactured construction aggregates. The process tailors aggregate properties to specific applications, such as aggregates for manufacture of lightweight concrete blocks, structural lightweight concrete, or aggregates for use in asphalt road paving. The process consists of mixing, extrusion, and moderate-temperature curing. It takes advantage of the cementitious properties of the extruded products for strength development. Optimizing the water addition and time during the mixing step in addition to identifying the proper conditions for curing are important factors for the production of aggregates with high strength and other desirable properties for use in construction. A proprietary curing method has been developed to optimize aggregate strength. The Universal Aggregates process represents an advance in the state of the art, and as a result was granted two U.S. patents (others are pending). In these two patents, process schemes to produce manufactured aggregates from various FGD materials are discussed.

Spray dryer ash, water, and other recycle materials are fed to a pug mixer where the materials are blended together. This mixing produces a uniformly blended loose, moist, granular material that feeds to an extruder. The extruder has an auger that subjects the material to further mixing under vacuum and then forces the material through a die (metal plate with drilled or specially shaped holes).

Wet, "green" pellets (or extrudates) from the extruder are soft and must be transferred to a curing vessel for hardening. A belt conveyor transfers the short, soft, wet extrusions ("green" pellets) to a large slow turning tumbler where the pellets are tumbled with embedding material. The green pellets and embedding material discharge from the tumbler to a belt conveyor that feeds the curing vessel. The purpose of the embedding material is to coat the green pellets with dry material and to fill in the void spaces between the pellets. This cushions the pellets as they move through the curing vessel and prevents agglomeration of the curing vessel charge by minimizing contact between green pellets. The curing vessel is a specially designed retention bin that provides for flow of solids without channeling or hang-up. To minimize system heat losses, the vessel is also heat traced and insulated. The heat tracing is not used to raise the solids temperature, but provides enough heat to insure that the curing vessel operates adiabatically.

The vessel is operated at a slight vacuum. The small amount of vent gas from the curing vessel is directed through a scrubber to remove particulate matter. The pellets cure or harden as they slowly move down through the vessel. The hardening is a result of cementitious and/or pozzolanic reactions occurring within the green pellets.

The formation of ettringite, a mineral with the formula $Ca_6A1_2(SO_4)_3(OH)_{12}{\cdot}26H_2O$ or $Ca_6A1_2(SO_3)_3(OH)_{12}{\cdot}26H_2O$, is thought to be responsible for much of the pellet hardening. Spray dryer ash contains the essential components for the formation of ettringite. After curing, the hardened pellets (manufactured aggregates) are screened to remove fines and sent to crushing operations.

Screened pellets are fed to the crushing section. The crusher reduces the size of the cured pellets to a size suitable for use by concrete block plants. The crushed material feeds a screen that splits the crushed aggregate into three streams: oversize material, product, and fines. The oversize material (i. e. +3/8”) feeds back into the system through a bucket elevator to the crusher and is re-cycled to extinction. The middle screen product, which is predominately 3/8" x 18 mesh, is sent to a stockpile via a belt conveyor/stacker. The –18 mesh fines go to an air classifier that uses air classification to efficiently strip - 100 mesh fines from the relatively coarse – 18 mesh fines. The -100 mesh fines from the inertial separator are collected in the baghouse and are recycled back to the process. The 18 x 100 mesh fines were sent to the stockpile as products. In setting up the crushing system, efforts are made to minimize the production of fines and the need for fines recycle.

(2) Operations and Safety Training

Throughout plant construction and Start–up, Safety and Safety Training is an important component of the workplace. All employees of Universal Aggregates have to work under safety standards. Corporate safety policy is cultured and enforced by a team of health and safety professionals. Each employee is issued a copy of the corporate safety policies, and is expected to adhere to them. Management and operations work together to maintain the proper safety attitude and practice.

Safety inspections are performed regularly by the companies’ Health and Safety Department. A regional Safety Manager is assigned to Universal Aggregates’ Birchwood facility. This provides regular professional consultation and communication with the management and operations team at the plant. The companies’ V.P. of Safety and the Regional Safety Manager are personally familiar with Universal Aggregates’ manufacturing plant at the Birchwood site, and are also familiar with Universal Aggregates’ manufacturing process. Standard safety training and operational specific safety training are both conducted.
All plant employees undergo First Aid and CPR training. Regular “Tool Box Talks” and safety meetings are scheduled, conducted, and documented by each shift foreman.

A “Facility Safety Checklist” is regularly conducted by the shift foremen, and recorded. Any safety deficiencies are brought to the attention of the Plant Manager, and are corrected.

The Health and Safety Department maintains a “Library” specifically for safety awareness and training. Written materials and training videos are supplied for toolbox talks and specific safety training needs. When required, consulting safety specialists are also contracted to address specific training needs.

A site specific Emergency Response Plan has been prepared for Universal Aggregates’ Birchwood plant. Each employee is provided with a written copy. A bound copy of the plan is also available in the Plant Managers office. The Emergency Response Plan is appropriately labeled, and in plain view in the event that emergency information is needed.

On site, all plant employees wear appropriate clothing and safety gear.
Uniforms and uniform cleaning services are provided for each employee.
All employees and visitors are required to wear hard hats and appropriate eye protection. Steel toe shoes are required as appropriate foot protection. Gloves, disposable dust masks, and disposable hearing protection are supplied to the employees as needed. Eye wash stations, fire extinguishers, and first aid kits are located in the plant office and within the plant. Appropriate fall protection devices are maintained on-site for the employees’ use when needed.

All employees are supplied with radio communication. The radio communication is also combined with direct monitoring of the power station’s communication network in the event of a power station, or general site emergency.

Site evacuation training drills have been conducted by the power station’s Health and Safety Officer.

An MSDS binder is maintained and available to all employees at the plant.

(3) Equipment and Maintenance

On the job training is performed with all employees at Universal Aggregates’ Birchwood plant, no matter what type of previous background experience of the employee.

The Plant Manager has twenty–three years of manufacturing experience in operations and management of extruded, clay brick production.

This type of heavy industrial experience is critical in understanding the operation and maintenance of equipment, and provides the fundamental experience required to manage a commercial production facility of this type.
Although equipment modifications were required for Universal Aggregates' process application, the principles and mechanics of extrusion are the same. In Universal Aggregates' process, the basic manufacture steps are also similar: Proportioning and Mixing, Agglomeration, and Curing. In the case of the aggregate operation "Sizing" (crushing and screening) and the stockpile replaces Pallets and wrapping cubes of brick.

Universal Aggregates' operating staff has varied industrial experience in electrical, mechanical and heavy construction trades. Each shift has a working Foreman, responsible to the Plant Manager.
The plant operates on two (2), twelve (12) hour shifts, seven (7) days per week; three (3) days "on", followed by three (3) days "off", then alternating to four (4) days "on" followed by four (4) days "off".

Twenty employees currently make up the full complement of hourly and salary positions at Universal Aggregates' Birchwood manufacturing plant.

Each shift performs preventive maintenance, and any equipment repairs as required. Occasionally, a mechanical subcontractor is hired to assist the operating staff with plant modifications and repairs. In addition, a local "Temporary" agency occasionally supplies contracted labor for light duty cleaning, or unskilled labor needs.

Equipment maintenance schedules and logs are maintained at the plant to assist each shift Foreman of routine, and scheduled equipment maintenance needs, and in tracking equipment performance. Operation and maintenance manuals are maintained at the plant with access to any employee. Universal Aggregates' Engineering and management staff corresponds with equipment vendors and fabricators in troubleshooting, equipment upgrades or modifications and repairs.

Most of the process knowledge required to formulate the initial operating procedures were based upon Universal Aggregates' previous "Pilot Plant" operating experience. The "Pilot Plant" provided the fundamental material balance design data, and the operating experience necessary for control sequence and equipment integration. The "Pilot Plant" experience also provided the fundamental knowledge necessary for equipment selection and plant design, equipment performance review, and modification.

With the current level of integrated, commercial-scale operating experience at the Birchwood plant, UA is developing "Routine" operating and maintenance procedures..

“Routine procedures” such as designed operating parameters, specified replacement parts, or regular lubrication is predetermined by the equipment manufacturer. On the other hand, items such as cleaning, and wear parts are more determined by actual use and performance.

As UA proceeds through commercial start–up, and increases operating capacity, the plant’s operating staff has become more and more attentive to process details and operating procedure.

(4) Equipment and Operating Procedures

<u>SDA Feed System (see “Process Flow Diagram” on page 2–16)</u>

The existing Spray Dryer Ash (SDA) Silo F-110 receives SDA from the Power Plant and transfers it to the SDA Daybin F-120 via two blowers (JB-110A and JB-110B), one operational and one stand-by. The Silo has an existing Level Transmitter (LT1-F110), two Flow Valves (FV1-F110 & FV2-F110), two solenoid controlled Air Slides (SV1-F110 & SV2-F110) and one Rotary Feeder Valve (RF-110). Discharge control of the SDA Silo F-110 will be through the Aggregate Plant PLC. Also, an automatic Product Line Sampler is provided on the incoming Silo feed line.

The SDA Daybin (F-120) feeds SDA to Two (2) Weigh Feeders (K-120A and K120B) via Screw Conveyors L-120A and L-120B respectively. The Day Bin has a Level Transmitter (LT1-F120), Manual Gate Valves (MG-120A and MG-120B), Manually controlled Air Slides for each leg (AS-120A & AS-120B) and a Bagfilter (BF-120C).

Blower (BF-120C) draws air from the SDA Day Bin (F-120) through the Bag Filter (BF-120C) and vents to atmosphere.

SDA Weigh Feeder K-120A is a self-contained operating unit. Based on operator entered parameters, the unit will continually batch material from the SDA Day Bin F-120 via screw conveyor L-120A to screw conveyor L-310A. The Feeder also has a self contained Bagfilter (BF-120A).

SDA Weigh Feeder K-120B is a self-contained operating unit. Based on operator entered parameters, the unit will continually batch material from the SDA Day Bin F-120 via screw conveyor L-120B to screw conveyor L-320. The Feeder also has a self contained Bagfilter (BF-120B).

Additive No 1 System

The Additive No.1 Silo F-210 receives material from a pneumatic truck fill station and transfers it to screw conveyor L-210. The Silo has a Level Transmitter (LT1-F210), Manual Gate Valve (MG-210), manually operated Air Slide, Live Bottom Discharge (M1-BV210) and Bagfilter (BF-210A).

Blower (BF-210A) draws air from the Additive #1 Silo (F-210) through the Bag Filter (BF-210A) and vents to atmosphere.
Screw Conveyor L-210 supplies Additive #1 material to the Additive #1 Weigh Feeder K-210.

Additive Weigh Feeder K-210 is a self-contained operating unit. Based on operator entered parameters, the unit will continually batch material from the Additive #1 Silo F-210 via screw conveyor L-210 to Additive #1 Pulverizer P-210. The Feeder also has a self contained Bagfilter (BF-210B).

Additive #1 Pulverizer P-210 supplies Additive #1 material from the Additive #1 Feeder K-210 to the Additive #1 Screw Conveyor L-320. The Pulverizer has one feeder motor (M2-P210), one main drive motor (M1-P210), a Chute Level Switch (LSHH-P210) and a Bagfilter (BF-210C).

Recycle System

The Recycle Daybin F-250 receives fines from screw conveyor L-250C and transfers it to screw conveyor L-250B. The Recycle Daybin has a Level Transmitter (LT1-F250), Level Switch (LSLL1-F250), manual Gate Valve (MG-250), manual Air Slide valve, Bin Activator (M1-BV250), and Bagfilter (BF-250).
Blower (M1-BF250A) draws air from the Recycle Daybin (F-250) through the Bag Filter (BF-250A) and vents to atmosphere.

Screw Conveyor L-250B supplies Fines from the Recycle Daybin F-250 to the Recycle Weigh Feeder K-250.

Recycle Weigh Feeder K-250 is a self-contained operating unit with Density Control (DE1-K250). Based on operator entered parameters the unit will continually batch material from the Recycle Daybin F-250 via screw conveyor L-250B to Recycle Screw Conveyor L310A. The Feeder also has a self contained Bag Filter (BF-250B).

Additive No. 2 System

Additive #2 Storage Tank F-220 is a heated storage tank containing Additive No. 2 and receives material from a truck fill station. The tank is a self-contained heated control unit. The tank has a Level Transmitter (LT1-F220), two additive Pumps (J-220A &J-220B), pump pressure control, temperature monitoring, and Pug Mill flow control/monitoring.

Two Additive Pumps (J-220A & J-220B), one operating and one standby, supply Additive No. 2 from the Additive #2 Storage Tank F-220 to the Pug Mill PM-310. Each Pump has its own discharge Pressure Switches. When pumps are not supplying Additive No. 2 to the Pug Mill, they are recycling material to and from the Additive Tank to retain the temperature.

Extruder System

Screw Conveyor L-310A supplies SDA and Fines from the SDA Weigh Feeder K-120A and the Recycle Weigh Feeder K-250 to the Pug Mill (PM-310).

The Pug Mill PM-310 consists of a motor, air-operated clutch, reduction gearbox and knives. The Pug Mill receives and blends SDA and Recycled Fines from conveyor L-310 together with water and Additive No. 2. This mix is then conveyed on to the Pug Sealer PS-310.

The Pug Sealer PS-310 consists of a motor, air-operated clutch, reduction gearbox, motor sheaves and V-belts. Material in the Pug Sealer continues to mix under vacuum to a designated consistency. Material is then conveyed into the Extruder E-310.

The Extruder E-310 consists of a motor, air-operated clutch, reduction gearbox, motor sheaves, V-belts, hydraulic die changer and a variable frequency drive. In the Extruder, the mix is formed into a 1” diameter green aggregate “noodle”.

The Aggregate Cutter AC-310 mounts on the Hydraulic Dye Changer frame on the outlet of the Extruder, and consists of a motor, variable frequency drive and limit switches. The Aggregate Cutter cuts the aggregate “noodles” formed by the Extruder into 2” long pieces.

Belt Conveyor L-310B, a forward and reversing conveyor, receives sized aggregate from the Aggregate Cutter (AC-310). When running in forward mode the conveyor transfers the aggregate to the Tumbler (T-320). When running in reverse mode the conveyor deposits the aggregate off line.

Tumbler

Screw Conveyor L-320 supplies SDA and Additive #1 from the SDA Weigh Feeder K-120B and the Additive #1 Pulverizer P-210 to the Tumbler (T320).

In addition, Belt Conveyor L-310B supplies sized “green” aggregate noodles from the Extruder E-310 to the Tumbler (T320). The Tumbler then mixes these products and conveys the aggregate and embedding onto Belt Conveyor L-41.

Curing Process System

Belt Conveyor L-410A receives “green” aggregate and embedding material from the Tumbler T-320 and conveys these products into the Curing Vessel (C-410) through the Dust Collection Hood Distribution Hopper (DH-410A). The aggregate is held in the Curing Vessel for a calculated time period, as controlled by the vessel discharge rate, and discharged onto Reversing Belt Conveyor L-410F.

The Curing Vessel has the following components:

- One Dust Collection Hood Distribution Hopper (DH-410A). The Dust Collection Distribution Hopper level is controlled and monitored by a level transmitter (LT1-DH410).

- Four Curing Vessel air actuated gates (AG-410A, AG-410B, AG-410C &AG-410D). The gates are controlled through the PLC. The PLC monitors the Distribution Hopper's level via Level Transmitter (LT1-DH410).

- Four Curing Vessel Distribution Hoppers
  Hopper Level is controlled and monitored by individual Hopper Level Transmitters (LT1-C410, LT2-C410, LT3-C410 & LT4-C410).

- TE2-C410, TE3-C410, TE4-C410, TE5-C410, TE6-C410, TE7-C410 & TE8-C410). Eight Temperature Elements/Transmitters (TE1-C410).

- Three manually operated Curing Vessel Discharge Gates (MG-410A, MG-410B & MG-410C) discharging onto three Belt Feeders L-410B, L-410C & L-410D, which discharge onto Belt Conveyor L-410F.

Belt Conveyor L-410F receives product from the Curing Vessel (C-410) and conveys the product to Belt Conveyor L-510A.

Dust Collector Hood (DH-410B) is located at the transfer point of Belt Conveyor L-410F and Belt Conveyor L-510A. Dust Collector DC-410 services Dust Collector Hood DH-410B and transfers the resulting fines to Conveyor L-510A. The Dust Collector has a self-contained timer activated air blast system, Rotary Feeder Valve (RF-520), vent blower (JB-520) and Differential Pressure switch (DPSI-DC410). Blower (JB-410) draws air from the Dust Collection Hood DH-410B through the Dust Collector (DC-410) and vents to atmosphere.

Curing Vessel Scrubber System

Blower (JB-420) draws air from the Curing Vessel Dust Collection Hood (DH-410A) through a Wet Scrubber (B-420) and vents to atmosphere. The Wet Scrubber B-420 is a Venturi Scrubber and Cyclone Separator. The Scrubber is used to remove fine particles from the atmosphere, which is drawn from the Dust Collection Hood on top of Curing Vessel C-410 (This system is currently in the process of modification through the incorporation of four bin vents located atop each of the four curing vessel distribution cans).

Screening / Crushing System

Belt Conveyor L-510A receives product from Belt Conveyor L-410F and conveys the product into Primary Screen G-510A. Primary Screen G-510A has two Forward and Reversing Screening Motors (M1-G510A & M2-G510A).
After primary screening the screened product flows through Dust Collector and Transition Chute (DH-510B) into the Horizontal Impactor (HI510). The Impactor then reduces the product and gravity feeds to the Secondary Screen G-510B. Secondary Screen G-510B has one Forward Screening Motor (M1-G510B). After secondary screening, the screened product flows onto Belt Conveyor (L-510C).

Product fines from Primary Screen G-510A and Secondary Screen G-510B are gravity fed into the Gravitational Classifier GC-510 for excess fines removal. Product which passes the Gravitational Classifier GC-510, flows onto Belt Conveyor (L-510C).

The Classifier Baghouse B-520 receives product from the Gravitational Classifier (CG-510) and transfers the resulting fines to Screw Conveyor L-250A.

Recycle System

Screw Conveyor L-250A supplies recycle and fines from the Primary Screen (G-510A) and the Classifier Baghouse (B-520) to Bucket Elevator (BE-250).

Bucket Elevator (BE-250) conveys the material to Screw Conveyor L-250C.

Screw Conveyor L-250C supplies fines to the Recycle Daybin (F-250).

Product Delivery System

Belt Conveyor L-510C receives product from the Secondary Screen G-510B and Gravitational Classifier GC-510, and conveys the product onto Telescoping Belt Conveyor L-510D. Belt Conveyor L-510C contains Belt Weigh Scale (WE-L510C) and Totalizer for weighing and totalizing processed product.

Telescoping Belt Conveyor L-510D receives product from Belt Conveyor L-510C and conveys the product onto the stockpile. The conveyor is also capable of telescoping in and out (M4-L510D), raising and lowering (M2-510D), and moving left and right (M3-L510D).

Finished product is loaded from the stockpile into trucks with a front end loader. Trucks are weighed on the Truck Scale TS-540 to determine product weight to be delivered to customers.

(5) QA/QC Procedures

A QA/QC program was implemented to monitor qualities of green extrudates from extruder die, curing vessel charge (blend of extrudates and embedding material) and discharge (blend of cured extrudates and embedding material) for process control. In addition, qualities of SDA, recycle and crushed aggregate products are monitored for correlation during aggregate production. The QA/QC program for the initial integration run is provided in Appendix C.

Qualities of green extrudates determined include moisture content, temperature, penetrometer reading and deflection upon dropping (10 ft). Moisture content is an indication of mixing and extrusion performance and is related to water absorption and quality of aggregate produced. Temperature is related to the pugsealer and extruder operation. Penetrometer reading is directly related to internal cohesion and shear of the compacted extrudates, which is dependent on mix design and mixing and extrusion performance. Deflection is an indication of structural integrity, as determined by angle of deflection and number of cracks upon 10 ft dropping. Moisture content, penetrometer reading and deflection of green extrudates must meet specifications for extrusion during long-term tests.

Qualities of curing vessel charge determined include temperature of the blend, penetrometer reading of extrudates and moisture content of embedding material. Temperature of the blend is related to exothermal reaction of additive #1 upon wetting in embedding material and is an indication of additive #1 reactivity. Penetrometer reading of extrudates is related to internal cohesion and shear strength of extrudates charged to curing vessel. Moisture content of embedding material is an indication of compressibility of embedding material in curing vessel. Temperature, penetrometer reading and moisture content must meet specifications for curing vessel charge to avoid lump formation and maintain mass flow in curing vessel.

Qualities of curing vessel discharge determined include temperature of the discharge (blend of cured extrudates and embedding material), moisture content of cured embedding material and crush strength of cured extrudates. Temperature of the blend and moisture content of the cured embedding material are related to the performance of curing vessel. Crush strength of cured extrudates are related to the performance of curing vessel and quality of aggregate products. Temperature, moisture content and crush strength must meet specifications for aggregate production during long-term tests.

Qualities of SDA, recycle and crushed aggregate products determined include carbon content of SDA, moisture content and size gradation of recycle, size gradation, bulk density and fineness modulus (FM) of crushed aggregate products.

Carbon content of SDA can affect water and additive addition in mix formulation and quality of green extrudates. High amounts of water and additive addition are required to be added in the mix with SDA of high carbon content. Carbon content in SDA is mostly related to coal pulverization operation and boiler combustion conditions at the power plant. Moisture content and size gradation of recycle are related to operation conditions and performance of curing vessel, screen and air classifier. Size gradation, bulk density and FM of crushed aggregate products are related to strength of extrudates and operation conditions and performance of crusher, screen and air classifier. Qualities of crushed aggregate products must meet customer's specifications for use in CMU production.

4.2.1 Instrumentation and Data Acquisition

(1) Plant Controls and PANELMATE

Plant operators normally use the plant's Programmable Logic Controller (PLC) to put equipment in service, take equipment out of service, adjust controls, and monitor process operations. The PLC is a powerful tool that automatically controls most of the equipment sequencing operations and provides proper time – in and time – out periods for equipment clearing. Control of the PLC is through a graphical interface touch screen (PANELMATE), which is located in the operator station on the second level of the process building.

Currently, the PLC graphical interface has 37 screens that can be viewed by operators. The first screen is a menu of touch screen buttons for the remaining 36 screens. An operator can access any of the other screens by simply touching the desired screen button. The color code convention for the PLC screens is RED for equipment that is off and GREEN for operating equipment.

All of the PANELMATE control screens, data input, and monitoring is downloadable through a PC interface. For example:

- Solids rates – SDA, recycle, embedding SDA, and Additive #1
- Liquid Additive #2 rate
- Water rate
- Stability of flow rates
- Tank and silo levels
- Curing Vessel distribution can levels
- Curing Vessel discharge and recirculation rates
- Rotary chute timing, and indicing for charging curing vessel distribution cans
- Operating amperages for pugmill, Pug sealer and Extruder

(2) List of Continuous Process Monitors for the Manufactured Aggregate Process at Birchwood:

SDA to 120 A (feeder to pugmill) (lb/hr rate and total cumulative weight)
SDA to 120 B (feeder to tumbler) (lb/hr rate) and total cumulative weight)
Process Water to pugmill (lb/hr rate & temperature)
Recycle feed (feeder to pugmill) (lb/hr rate)
Solids additive #1 (feeder to pulverizer/tumbler) (lb/hr rate)
Liquid Addmixture #2 to pugmill (lb/hr rate) (temperature local)
Steam Skid (pressure and temperature local)
SDA Daybin level (%)
Recycle Daybin level (%)
Solids Additive #1 Silo level (%)
Process Water Tank level (%)
Liquid Admixture #2 Tank level (%)

Pugmill amperage (speed control to be introduced)
Pugsealer amperage and speed, and vacuum (local)
Extruder amperage and speed

410 B, C, D (Curing Vessel discharge conveyor speeds, & motor settings)
410 A conveyor to Curing Vessel (combined weight of products, lbs/hr rate, & belt speed setting)
510 A conveyor to process bldg. (lb/hr rate and cumulative tonnage, & belt speed setting)

Curing Vessel distribution can levels (%)
Curing Vessel loading into distribution cans A, B, C, D (location)
CuringVessel Operating Temperatures

Aggregate stacker conveyor (lbs/hr rate & total cumulative tonnage)

All baghouse pressure controls and timers (local)

All Binvent pressure controls and timers (local)

Truck scale (product tonnage shipped)

4.2.2 Test Methods

The table shown below provides the stream properties determined, sampling points and frequency, and test methods used for monitoring process control and products quality during integration runs for aggregate production. Test methods include both ASTM and UA test methods. Procedures of UA test methods are described in Appendix F.

TEST VARIABLES DURING INTEGRATION RUNS FOR AGGREGATE PRODUCTION

Test Stream Properties	Sampling Points	Frequency	Method
Green Extrudates Penetrometer reading Deflection, % Moisture, wt% dry	Outlet of extrusion die	Once per hour during initial extrusion and integration operation	UA method UA method Moisture analyzer
Recycle Moisture content, wt% dry Size gradation, wt%	Underneath screw feeder L-250B	As requested during integration operation	Moisture analyzer ASTM C136
Blend of Extrudates and Embedding Material Temperature of the blend, °F Penetrometer reading of extrudates Moisture of embedding material, wt% dry	Top of the conveyer belt L-410A	Once per hour during initial extrusion and integration operation	UA method UA method Moisture analyzer
Blend of Cured Extrudates and Embedding Material Temperature of the blend °F Crush strength of cured extrudates, lb	Belt feeder L-410F at bottom of curing vessel	As requested during integration operation	UA method UA method
Aggregate Products Unit weight, lb/ft^3 Fineness Modulus Size gradation	Automatic sampler (AS-510) at belt conveyor L-510C or aggregate stockpile	As requested by customers	ASTM C29 ASTM C136 ASTM C136
Spray Dryer Ash Moisture content, wt% Hydrated lime Carbon content	Underneath screw feeder L-120A	Once a day during operation	Moisture analyzer ASTM C25 UA method

4.3 Analyses of Feed Stocks, Products and Reagents

Feed stocks characterized include SDA and recycle. Products and reagent characterized include crushed aggregate products and additives (#1 and #2).

SDA samples collected from the screw conveyor L-120A were routinely characterized for hydrated lime and carbon contents during operation of the processing plant and integration run for aggregate production. Carbon contents were determined only after January 2005. The average monthly hydrated lime contents and monthly ranges of carbon contents are shown in Table 4. Hydrated lime content in spray dryer ash is related to spray dryer operation at the power plant.

Carbon content in spray dryer ash is related to coal combustion and coal pulverizer operations. As shown in Table 4 in Page T-8, hydrated lime contents in SDA decreased from mid or high 20% to low 20% in October 2004, after Birchwood power plant implemented a spray dryer modification operation at the request of Universal aggregates. Hydrated lime contents decreased to below 20% in April 2005 after further improvement in spray dryer operation. The carbon contents in SDA were mostly in the range of 3.9% to 6.2%. With adjustment of additive addition, SDA with these carbon contents are adequate for extrusion.

The compositions of spray dryer ash collected monthly for analyses are listed in Table 5 in Page T-9. Ultimate analyses show variations in carbon, hydrogen, nitrogen, sulfur and ash contents. Major element analyses show variations in SiO_2, Al_2O_3, Fe_2O_3, CaO and SO_3 contents and others. SiO_2, Al_2O_3 and Fe_2O_3 contents are related to the amount of coal fly ash contained in spray dryer ash. CaO and SO_3 contents are related to the amounts of unused sorbent (i. e., hydrated lime) and spent sorbent (i. e., calcium sulfite and calcium sulfate) remaining in spray dryer ash.

Table 5 also includes hydrated lime content, the total amount of SiO_2, Al_2O_3 and Fe_2O_3 and calcium utilization for comparison. Calcium utilization is calculated based on molar ratio of sulfur to calcium in spray dryer ash and is an indication of sulfur removal efficiency in spray dryer operation.

Recycle collected from the screw feeder L-250B was characterized for moisture contents and grain size distribution during integration run. Aggregate products collected from automatic sampler (AS-510) or stockpile was characterized for bulk density, size gradation and fineness modulus (FM) during integration run. Sample of Additive #1 collected by the vender during shipment was characterized for available alkaline material, reactivity and inert materials in Additive #1.

4.4 Data Analysis Methodology

Aggregate production and SDA consumption are two important end parameters in an integration run for aggregate production at the Manufactured aggregate plant. A sufficient amount of aggregates has to be produced for customer uses. SDA consumption has to match with SDA production at the Birchwood Power station, which is a peak load plant and dependent on dispatch requirement of the electricity grid. Both aggregate production and SDA consumption are related to mix formulation (SDA, water, recycle and additive). An example is shown in Table 6 in Page T-10. The calculation is based on 20,000 lb/hr SDA from K120A and 32% moisture content in green extrudates with 2,000 lb/hr incremental increase of recycle, until it reaches material balance with net recycle production of zero.

As shown in Table 6, crushed aggregate production increased from 22,791 lb/hr (11.40 ton/hr) to 38,057 (19.03 ton/hr) and SDA consumption increased from 24,961 lb/hr (12.48 ton/hr) to 28,330 lb/hr (14.16 ton/hr), as recycle feedrate increased from 0 lb/hr to 15,178 lb/hr (7.59 lb/hr) in the material balance run. During this demonstration, recycle consumption is often limited by operation performance of equipment such as the mixer, weight feeder and extruder, and by the qualities of extrudates such as high moisture content and low penetrometer reading. If net recycle material production is greater than zero, it will fill up the recycle daybin (F-250). Extrusion runs must be conducted to empty the recycle daybin without curing vessel charge and aggregate production. A continuous long-term integration run for aggregate production must be conducted at full, material balance and process integration.

In the integration run with recycle production, data analysis is based on the relationship among mix components, SDA consumption, net recycle production and crushed aggregate production, as shown in Table 6. In the extrusion run without recycle production, data analysis is based on the relationship between mix components and SDA consumption.

4.5 Data Summary

The table below summaries integration runs with recycle addition and aggregate production from December 2004 to December 2006, except those in July 2006. The table includes ranges of SDA feedrates from K120A and K120B, ranges of recycle feedrate and monthly aggregate production. In July 2006, aggregate production was conducted without recycle addition near end of the month (July 25 – July 31) and after the curing vessel refill with a blend of limestone and lightweight aggregates.

MONTHLY RANGES OF SDA (K120A AND K120B) AND RECYCLE FEEDRATES AND AGGREGATE PRODUCTION DURING INTEGRATION RUNS FROM DECEMBER 2004 TO DECEMBER 2006

Monthly Date	SDA, lb/hr (K120A)	SDA, lb/hr (K120B)	Recycle, lb/hr (K250)	Aggregate Production, ton
December 2004	12,000	3,980 - 7,470	4,000 -11,820	580
January to March 2005	8,000 - 10,000	2,000 - 3,685	700 - 3,670	450
September 2005	15,000 - 22,000	5,500 - 8,500	2,500 - 12,000	1,500
December 2005	13,500 - 22,000	6,100 - 9,150	8,100 - 13,500	800
January 2006	19,000 - 29,000	8,178	4,000 - 14,000	700
February 2006	27,000 - 29,000	8,178 - 8,216	4,000 - 9,000	965
March 2006	26,000 - 29,000	8,178 - 8,716	4,000 - 9,000	627
July 2006	29,000	7126	0	900
August 2006	22,000 - 29,000	7,126 - 7,880	2,000 - 7,000	3,036
September 2006	11,000 - 26,000	4325 - 8,182	2,000 - 7,000	1,732
December 2006	12,000 - 26,000	3,645 - 7,591	3,000 - 5,000	1,276

As shown in the above table, a total of 580, 2,720 and 9,236 tons of crushed aggregates were produced in 2004, 2005 and 2006, respectively. Test conditions and results of curing vessel charge for selected months are listed in the attached tables for reference. Tables 7, 8, 9, 10, 11 and 12 listed in Pages T-11, T-12, T-13, T-14, T-15 and T–16, respectively, cover test conditions and qualities of curing vessel charge with recycle addition during integration runs in August 2006. Table 13 listed in Page T-17 covers test conditions and qualities of green extrudates and curing vessel charge with recycle addition during integration runs in January 2006. Table 15 listed in Page T-19 covers test conditions and qualities of curing vessel charge with recycle addition in September 2006. Tables 17, 18 and 19 listed in Pages T-21, -22, T-23, -24 and T-25, -26 cover test conditions of green extrudates and curing vessel charge with recycle addition during integration runs in December 2006. In general, the integration runs conducted during August, September and December 2006 had longer duration of integration, due to associated equipment modifications and operation improvements.

The table below summarizes properties of crushed aggregates produced from December 2004 to December 2006. The tables include average and range of unit weights (as-is and dry) and fineness modulus (FM) of aggregates produced from December 2004 to December 2006.

AVERAGE AND RANGE OF UNIT WEIGHT AND FINENESS MODULUS OF CRUSHED AGGREGATES PRODUCED FROM DECEMBER 2004 TO DECEMBER 2006

Monthly Date	Unit weight, lb/ft^3		Fineness Modulus
	As-is	Dry	
December 2004			
Average	62.02	57.36	2.72
Range	60.68 – 62.86	55.64 – 59.91	2.38 – 2.96
September 2005			
Average	67.21	61.47	3.57
Range	64.32 – 70.56	55.86 – 65.90	3.24 – 3.87
December 2005			
Average	57.38	52,23	3.26
Range	55.17 – 58.48	50.76 – 54.07	3.10 – 3.33
January 2006			
Average	57.38	51.31	4.20
Range	56.27 – 58.48	50.76 - 51.86	4.11 – 4.28
February 2006			
Average	59.58	54.07	3.81
Range	59.58	54.07	3.81
March 2006			
Average	61.79	55.92	4.21
Range	61.79	55.92	4.21
July 2006			
Average	72.83	71.72	4.32
Range	72.83	71.72	4.32
August 2006			
Average	65.52	60.11	4.26
Range	62.06 – 69.52	54.05 – 66.20	3.80 – 4.73
September 2006			
Average	62.31	56.32	3.84
Range	55.08 –66.20	54.07 – 59.58	3.75 – 3.99
December 2006			
Average	62.80	54.33	3.95
Range	60.25 – 66.20	52.18 – 57.38	3.70 – 4.25

As shown in the above table, aggregates produced had average dry unit weights from 51.31 lb/ft^3 to 56.32 lb/ft^3 except in December 2004 (57.36 lb/ft^3), September 2005 (61.47 lb/ft^3), July 2006 (71.72 lb/ft^3), and August 2006 (60.11 lb/ft^3). The higher unit weights in these months are related to crushed aggregates containing other lightweight aggregates and/or limestone. An expanded shale aggregate was purchased and used to fill curing vessel for initial start-up in December 2004. A blend of these lightweight aggregates and limestone was used to refill the empty curing vessel after cleaning in August 2005 and July 2006. The expanded shale/limestone blend exhibits higher unit weight than aggregate produced from SDA. Dry unit weights of crushed aggregates produced from SDA meet ASTM C331 specification for combined lightweight aggregate (65 lb/ft^3, max.). Fineness modulus is related to size gradation of crushed aggregates as discussed below.

The table below summarizes averages and ranges of size gradation (3/8” x 8 mesh, 8 x 50 mesh and –50 mesh) of crushed aggregates produced from December 2004 to December 2006.

SIZE GRADATION OF CRUSHED AGGREGATES PRODUCED FROM DECEMBER 2004 TO DECEMBER 2006

Monthly Date	Size Gradation, wt%		
	3/8 x 8 mesh	8 x 50 mesh	- 50 mesh
December 2004	49.4 – 57.2	31.1 – 37.7	10.4 – 12.9
September 2005	51.7 - 72.3	21.0 – 39.1	5.6 – 6.6
December 2005	49.2 – 57.8	31.1 – 37.7	10.4 – 12.9
January 2006	44.6 – 52.9	37.8 – 38.4	9.3 – 17.0
February 2006	44.6	38.4	17.0
March 2006	52.9	37.8	9.3
July 2006	59.2	31.1	9.7
August 2006	42.9 – 71.8	25.0 – 41.0	6.8 – 14.7
September 2006	40.3 – 46.1	41.9 – 46.4	10.7 – 13.4
December 2006	31.1 – 48.4	42.2 – 57.7	4.4 – 9.2

As shown in the above table, the ranges of size gradation in 3/8” x 8 mesh were high in September 2005 (51.7% - 72.3%) and August 2006 (42.9% – 71.8%), which are related to the presence of limestone with high abrasion resistance in crushed aggregate. In comparison, the same ranges were low in September 2006 (40.3% - 46.1%) and December 2006 (31.1% - 48.4%), which are related to SDA aggregate and optimization of crusher to reduce size reduction in 3/8” x 8 mesh. The range of size gradation in - 50 mesh is low (4.4% - 9.2%) in December 2006, which is related to the optimization of air classifier to reduce size gradation in – 100 mesh. In general, aggregate customers were satisfied with size gradation of crushed aggregates for use in CMU production, especially those produced in September and December 2006.

The table below summarizes ranges of moisture content and size gradation (16 X 30 mesh. 30 x 100 mesh and –100 mesh) of recycle during integration runs from September 2005 to December 2006. Moisture content and size gradation of recycle are related to curing vessel operation. Size gradation is also related to the operation of the primary screen.

MOISTURE CONTENTS AND SIZE GRADATION OF RECYCLE GENERATED FROM SEPTEMBER 2005 TO SEPTEMBER 2006

Monthly Date	Moisture Content, wt% dry	Size Gradation, wt% total		
		16 x 30 mesh	30 x 100 mesh	- 100 mesh
September 2005	6.73 – 11.11	10.5 – 13.5	17.2 – 25.1	55.6 – 67.2
November 2005	9.26 – 12.07	7.6 – 15.0	19.0 – 22.6	62.0 – 73.3
December 2005	10.10 – 11.77	9.7 – 10.8	16.5 – 19.2	70.3 –73.6
February 2006	8.77 – 10.22	12.8 – 16.6	15.5 – 26.4	56.7 – 63.9
March 2006	14.47 – 15.13	18.0 – 20.2	23.9 – 24.7	54.1 – 57.3
August 2006	7.42 - 9.69	1.5 – 6.9	14.2 – 21.2	71.9 – 82.2
September 2006	8.64 – 11.47	5.4 – 5.8	17.0 – 17.5	77.1 – 77.2
December 2006	9.54 – 10.75	---	---	---

As shown in the above table, the relatively high moisture content (14.47% - 15.13%) and size gradation (18.0 % - 20.2%) in March 2006 is related to operation problems of curing vessel operation such as chucks formation. The low size gradation of 16 x 30 mesh in August 2006 (1.5% to 6.9%) and September 2006 (5.4% to 5.8%) are related to replace the –16 mesh (TBC) screen deck with a –18 mesh (TBC) screen deck in primary screen to remove 16 x 18 mesh fines from recycle for use as a mix component.

4.6 Operability and Reliability

4.6.1 Critical Component Failure Analysis

Several critical operation problems were identified during initial startup. These problems include inaccurate SDA feed control, lack of mixing and extrusion consistency, frequent extruder backup, uneven distribution of flow of material in the curing vessel and others.

These problems limited plant capacity and availability for aggregate production.

The problem for accurate control of SDA feed was caused by free flow of the aerated SDA. The aerated SDA is pneumatically conveyed from BPP silo to the UA manufactured aggregate plant SDA day bin. It can cause free flow flush, especially at high SDA throughput. The free flow problem was addressed by installing a new bin vent dust collector, establishing proper SDA day bin gate valve operation and by modifying screw feeder and weight feeder configurations to maintain accurate SDA feed. The problem for lack of mixing and extrusion consistency is caused by thioxotropic properties of SDA. It was addressed by installing a new water distribution system to improve water and ash contact and by modifying pugmill and pugsealer configurations to enhance mixing for extrusion. The problem for frequent extruder backup is caused by extruder design, which was made from brick production from clay, not for processing SDA.

The problem was addressed by refining the liner and die geometry in extruder, installing a porcelain enameled auger and a single wing gap point auger to improve extrusion capacity and availability.

The curing vessel problem was addressed by revising distribution chutes and by balancing and maintaining a minimum material flow in curing vessel. Other problems included ash quality and inadequate equipment design. The solution of these problems are discussed in 3.1 “Design and Equipment Changes”.

The plant capacity and availability improved substantially after implementation of the above modifications. However, the plant availability for aggregate production is still limited by the amount of recycle, which can be incorporated as a mix component in pugmill. About 3,000 tons of crushed aggregate was generated in August 2006. In comparison, 8,000 to 10,000 tons of crushed aggregates should be generated in full production. A pugmill with a higher mixing capacity is required to process all generated recycle at the plant. A single-shaft pugmill was used during the project demonstration period ended at December 2006. A double-shaft pugmill was designed and would be used to increase mixing capacity to achieve full integration for aggregate production in *2007.*

5. TECHNICAL PERFORMANCE

The commercial demonstration of the manufactured aggregate process covers large-scale integrated operation of mixing, extrusion, curing, crushing and screening with weight feeders, screw and belt conveyors, bucket elevators, silos and baghouses, automatic control and other equipment for material handling and aggregate production. The curing vessel was a new design for use in a large-scale commercial application.

Operating variables include ash quality, mix formulation and relevant equipment in mixing, extrusion, curing, crushing, screening and material transfer. All of these are related to technical performance of the manufactured aggregate process. Effects of these operating variables on results and correlation of results are discussed below.

5.1 Effects of Operating Variables on Results

5.1.1. The effects of ash quality, mix formulation and equipment operating conditions of pugmill, pugsealer and extruder on characteristics of extruded products.

As discussed in the previous sections, ash quality, mix formulation, pugmill, pugsealer and extruder performance are important for extrusion operation and qualities of extruded products.

Ash quality includes carbon and hydrated lime contents. High carbon content could cause an increase of the water requirement in mix feed and moisture content of extruded products. High hydrated lime content can cause stickiness of wetted ash and make it difficult to extrude. Mix formulation with different amounts of SDA, recycle, water and additive can affect mixing in pugmill and pugsealer and extrusion in extruder. The ratio of recycle/SDA and the amount of additive can directly affect the performance of mixing and extrusion. Since SDA can exhibit thioxotropic properties, proper mixing is crucial for extrusion operation and qualities of extruded products. Several factors can improve mixing. These factors include consistent ash transfer from Birchwood ash silo, reliable performance of gravimetric weigh feeders for feed control and fine water distribution for better ash and water contact in injection water box. Operating conditions of pugmill, pugsealer and extruder can have direct effects on mixing and extrusion. Operating conditions of pugmill include mixing intensity and total throughput. Operating conditions of pugsealer include speed, shearing and transfer of mixed products under vacuum. Operating conditions of extruder include vacuum and speed. Extruder vacuum is identified as an important factor for structural integrity of extruded products, as indicated in penetrometer reading and deflection.

Modifications of pugmill, pugsealer and extruder to improve mixing and extrusion have been discussed previously in Sections 3.0 and 4.0.

5.1.2. The effects of operating conditions and qualities of curing vessel charge on curing vessel operation

Even distribution of curing vessel charge and the even flow of charged materials in the curing vessel are crucial for curing vessel operation. Modifications to the curing vessel charge regime and design were required to achieve even distribution and flow as discussed in Sections 3.0 and 4.0. Chunks (or lumps) were collected from the bottom of the curing vessel during the integration runs for aggregate production and curing vessel recirculation. Chunk formation can impede and disrupt continuous integrated operation for aggregate production. It was identified that chunk formation came from steam condensation in the curing vessel, excessive moisture in the embedding material, or lack of embedding material during curing vessel charge and uneven flow of charged materials during curing vessel operation. The ventilation systems of the curing vessel were re-designed to eliminate a water condensation problem. A QA/QC program was implemented to reduce or eliminate problems in curing vessel charge. Relevant equipment and operation procedures were modified to maintain even flow of the charged materials into the curing vessel. (See the previous discussion in Sections 3.0 and 4.0). Occasional recirculation of the curing vessel was conducted to prevent bridging, while the curing vessel was not in operation. After implementing these modifications, the curing vessel can be operated in balance, under mass flow conditions to provide adequate curing time and temperature for aggregate production.

5.1.3 The effects of operating conditions of screen, crusher and air classifier on characteristics of crushed aggregates

Size gradation and bulk density of crushed aggregates are related to operating conditions of screens, crusher and air classifier. Three and five decks with different size openings were selected for use in primary and secondary screens. Rotor speed and clearance between the breaker bars and plates in the crusher were adjusted to control product sizes. Openings of primary and secondary dampers and choke gate in air classifier were adjusted to control products fines (-100 mesh). During integration runs for aggregate production, crushed aggregates with proper size gradation and bulk density were produced to meet requirements for customers. This demonstrated that deck selection in primary and secondary screens and adjusted settings in both crusher and air classifier are adequate for aggregate production.

5.1.4. Others

In addition to mixing, extrusion, curing, crushing and screening, performance of other equipment is important for material transfer and handling, process control and aggregate production during integration operation. These equipment include a pneumatic ash delivery system for ash transfer from the BBP silo, mechanical screw feeders, belt conveyors and bucket elevators for material handling and transfer, baghouses and water spray system for dust control, automatic control for process operation and others. Modifications to these pieces of equipment have been discussed extensively in the previous sections. After implementing these modifications substantial improvements have been achieved in material handling, and the integration of the process operation as designed for aggregate production.

5.2 Correlation of Results

5.2.1 The effect of SDA Feedrate on moisture content of green extrudates

The two tables shown below compare the effect of high and low SDA throughput upon the moisture content of the green extrudates with, and without recycle addition. Runs were conducted with similar equipment operating conditions in December 2006. Test conditions and results of these runs without and with recycle addition are listed in Tables16, 17 and 18 (Pages T-20, T-21, -22 and T-23, -24) respectively. All moisture contents shown below were calculated on dry basis (wt% dry).

THE EFFECT OF SDA FEEDRATE ON MOISTURE CONTENT OF GREEN EXTRUDATES
(Without Recycle Addition)

Mix Component Feedrate, lb/hr		Green Extrudate Moisture Content, wt% dry
SDA Water Additive Recycle	26,000 –33,000 8,270 – 10,560 0 - 100 0	31.18 ± 0.40
SDA Water Additive Recycle	12,000 3,600 – 3,700 0 – 50 0	29.33 ± 0.47

THE EFFECT OF SDA FEEDRATE ON MOISTURE CONTENT OF GREEN EXTRUDATES
(With Recycle Addition)

Mix Component Feedrate, lb/hr		Green Extrudate Moisture Content, wt% dry
SDA	26,000	
Water	9,430 – 9,580	33.05±0.55
Additive	0 -122	
Recycle	5,000	
SDA	12,000	
Water	5,330 – 5,430	32.00 ± 0.93
Additive	0	
Recycle	5,000	

As shown in the first table above, green extrudates had moisture contents of 31.18± 0.40 % and 29.33 ± 0.47% at high SDA throughputs (26,000 – 33,000 lb/hr) and low SDA throughput (12,000 lb/hr) without recycle addition. In the second table, green extrudates had moisture contents of 33.05±0.55% and 32.00±0.93% at SDA throughputs of 26,000 lb/hr and 12,000 lb/hr with 5,000 lb/hr recycle addition. Moisture contents of green extrudates are higher with high SDA throughput than with low SDA throughput. The difference in moisture content with throughput is related to the thioxotropic properties of wet SDA and can be reduced by increasing mixing intensity, for example, with a double-shaft pugmill to replace the single-shaft pugmill.

5.2.2 The effect of recycle addition on moisture content of green extrudates

The tables below compare the effect of recycle addition on moisture content of green extrudates. Integration runs were conducted with similar equipment operating conditions in January and December 2006 for comparison. Test conditions and results of these integration runs are listed in Tables 13, 16, 17 and 18.

THE EFFECT OF RECYCLE ADDITION ON MOISTURE CONTENT OF GREEN EXTRUDATES
(January 2006)

Mix Component Feedrate, lb/hr		Green Extrudate Moisture Content wt% dry
SDA	19,000 - 25,000	
Additive	220 – 250	
Recycle	8,000 – 14,000	35.80 ± 0.52
Recycle /SDA Ratio	0.32 – 0.74	
SDA	29,000	
Additive	205 – 225	33.02±0.64
Recycle	4,000	
Recycle/SDA	0.14	

THE EFFECT OF RECYCLE ADDITION ON MOISTURE CONTENT OF GREEN EXTRUDATES (December 2006)

Mix Component Feedrate , lb/hr		Green Extrudate Moisture Content, wt% dry
SDA	26,000 – 33,000	31.18 ± 0.40
Additive	0 - 100	
Recycle	0	
Recycle/SDA	0	
SDA	26,000	33.05 ± 0.55
Additive	0 - 122	
Recycle	5,000	
Recycle/SDA	0.19	
SDA	12,000	29.33 ± 0.47
Additive	0 - 50	
Recycle	0	
Recycle/SDA	0	
SDA	12,000	32.00 ± 0.64
Additive	0	
Recycle	5,000	
Recycle/SDA	0.42	

As shown in the first table above, green extrudates had moisture content of 35.80 ± 0.52 % at high recycle addition (8,000 – 14,000 lb/hr) and recycle/SDA ratios of 0.32 to 0.74 and had moisture content of 33.02 ± 0.64% at low recycle addition (4,000 lb/hr) and recycle/SDA ratio of 0.14. In the second table, green extrudates had moisture contents of 31.18 ± 0.40% and 33.05 ± 0.55% with recycle/SDA ratios of 0 and 0.19 at high SDA throughput (26,000 – 33,000 lb/hr). In comparison, green extrudates had moisture contents of 29.33 ± 0.47% and 32.00 ± 0.64% with recycle/SDA ratios of 0 and 0.42 at low SDA throughput (12,000 lb/hr). From above, moisture contents of green extrudates are higher with recycle addition than without recycle addition. The high moisture content, especially at a high ratio of recycle/SDA and SDA throughput, is related to mixing intensity in the pugmill. Moisture content of green extrudates can be reduced with a double-shaft mixer to increase mixing intensity.

5.2.3. The effect of additive addition on operation of extrusion

The table shown below compares the effect of additive addition on operation of extrusion. Runs were conducted with similar equipment operating conditions in September 2006. Test conditions and results of these runs are listed in Table 20.

THE EFFECT OF ADDITIVE ADDITI0N ON MOISTURE CONTENT OF GREEN EXTRUDATES
(September 2006)

Mix Component Feedrate, lb/hr		Green Extrudate Moisture Content, wt% dry
SDA	26,000	
Water	8,350 – 8,400	32.95 ± 0.60
Additive	350	
Recycle	0	
SDA	12,000	
Water	3,600	29.45 ± 0.35
Additive	70 - 85	
Recycle	0	

As shown in the above table, addition of 350 lb/hr of additive in the mix is required to achieve continuous operation of extrusion with an SDA feedrate of 26,000 lb/hr and to produce green extrudates with moisture content of 32.95 ±0.60%. In comparison, only 70 to 85 lb/hr additive addition in mix is required to achieve continuous operation of extrusion with SDA feedrate of 12,000 lb/hr and to produce green extrudates with moisture content of 29.45 ± 0.35%. Higher SDA federate requires increased dosage of additive addition for extrusion. Additive addition is also dependent on pugmill, pugsealer and extruder operation, which is discussed next.

5.2.4 The effect of improved mixing and extrusion on additive addition and moisture content of green extrudates

The tables shown below compare the effect of improved mixing and extrusion on additive addition and moisture content of green extrudates with and without recycle addition. Due to the prolonged outage of BPP from September 23 to November 24 2006, knives in both pugmill and pugsealer were thoroughly cleaned and replaced. In addition, water spray box was cleaned and serviced. Extruder spiral liner was replaced with a new one-piece liner. Both mixing and extrusion operations were improved in December 2006. Test conditions and results of runs conducted in January, September and December 2006 were listed in Tables 13, 14 and 16 in Pages T-17, T-18 and T-19, T-20, respectively.

THE EFFECT OF IMPROVED MIXING AND EXTRUSION ON ADDITIVE ADDITION AND MOISTURE CONTENT OF GREEN EXTRUDATES
(September and December 2006)

Mix Component Feedrate, lb/hr		Green Extrudates Moisture Content, wt% dry
SDA	26,000	
Water	8,350 – 8,400	32.95 ± 0.60
Additive	350	
Recycle	0	
SDA	26,000 – 33,000	
Water	8,270 – 10,560	31.18 ± 0.40
Additive	0 - 100	
Recycle	0	

THE EFFECT OF IMPROVED MIXING AND EXTRUSION ON ADDITIVE ADDITION AND MOISTURE CONTENT OF GREEN EXTRUDATES
(January and December 2006)

Mix Component Federate, lb/hr		Green Extrudates Moisture Content, wt% dry
SDA Additive Recycle Recycle/SDA	29,000 205 - 250 4,000 0.14	33.02 ± 0.64
SDA Additive Recycle Recycle/SDA	26,000 0 - 122 5,000 0.19	33.05 ± 0.55

As shown in the first table above, additive addition was reduced from 350 lb/hr with SDA feedrate of 26,000 lb/hr in September 2006 to 0 – 100 lb/hr with SDA feedrates of 26,000 lb/hr to 33,000 lb/hr in December 2006. Moisture contents of green extrudates were reduced from 32.95±0.60% to 31.18±0.40%. In the second table, additive addition was reduced from 205 to 250 lb/hr with an SDA feedrate of 29,000 lb/hr and a recycle/SDA ratio of 0.14 in January 2006 to 0 to 122 lb/hr with SDA feedrate of 26,000 lb/hr and recycle/SDA ratio of 0.19 in December 2006. Moisture contents of green extrudates were similar at 33.02 ±0.64% and 33.05 ±0.55%. It was evident that improved mixing and extrusion in December 2006 can reduce additive usage and moisture content of green extrudates.

5.2.5 Update

From above, increasing SDA throughput and recycle/SDA ratio can cause increased moisture content in green extrudates. High moisture content is directly related to aggregate qualities such as high water absorption and drying shrinkage. During the project demonstration period, additive addition is necessary in runs with high throughput of feed materials. It was demonstrated that improved mixing and extrusion reduce additive addition and moisture content of green extrudates. As discussed in the previous sections, the plant availability for aggregate production was limited by the amount of recycle, which can be incorporated as a mix component in pugmill. Recycle/SDA ratios of 0.72 to 0.76 are required to process all generated recycle (i. e., material balance) with reduced moisture content of 32% or below in green extrudates as shown in Tables 2 and 3.

The objective to achieve complete material balance for continuous aggregate production was not achieved during the project demonstration period ended in December 2006. A single-shaft pugmill was used in mixing during the project demonstration. A double-shaft pugmill was designed and installed for operation to enhance mixing in February 2007. Aggregate production increased to about 5,200 tons in March 2007. Mix capacity has been improved substantially with reduced moisture contents in green extrudates at SDA and recycle throughputs up to 18,000 lb/hr and 14,400 lb/hr. Currently, the demonstration plant operated at 50% to 60% design capacity on a daily basis. Manufactured aggregates were sold to several regular customers in the production of concrete masonry. Additional pugmill optimization and equipment modifications will further improve aggregate production and qualities with high SDA and recycle throughputs to achieve full integration of SDA consumption and aggregate production at the plant.

6.0 ENVIRONMENTAL PERFORMANCE

6.1 Impact on the Environment

See DOE/EA – 1449 Environmental Assessment
United States Department of Energy, National Energy Technology Laboratory
"Commercial Demonstration of the Manufactured Aggregate Processing Technology Utilizing Spray Dryer Ash, King George County, Virginia" August, 2002

"No significant impacts to human health and safety or the environment are anticipated from the construction and operation of the proposed lightweight aggregate manufacturing facility. The proposed plant would be constructed on a previously disturbed site and no impacts to geology or soils would occur. Cultural resource investigations have been conducted and additional investigation was not warranted; therefore no further action pursuant to section 106 of the National Historic Preservation Act is required. No impacts are expected to ecological resources, or floodplains. Construction and operation of the proposed project would not be expected to impact any Federal or State listed threatened or endangered species. Although truck traffic would increase, roadways would be sufficient to handle the increased capacity, and therefore, transportation impacts would be minimal. Minor increases in noise and particulate matter (PM_{10}) would be expected."

"The proposed facility would utilize all of the spray – dryer ash produced by the Mirant – Birchwood Facility which is being used by the King George County Landfill as daily cover. Therefore, with project implementation, the landfill would have to secure other material for cover and could result in additional areas being disturbed for soil/sand borrow. Alternatives for cover do exist in the landfill industry that may be more environmentally sound, however. Furthermore, King George County would not receive the $5 per ton tipping fee that are currently being collected for disposal of the spray – dryer ash in the landfill, but the proposed facility would provide additional employment in the manufacturing sector and an increased tax base for the county. The King George Planning Commission has supported implementation of the proposed project in that they approved a special exemption and modification to the proffer statement from Mirant – Birchwood Facility to enable Universal Aggregates LLC, to design, construct and operate the lightweight manufactured aggregate facility."

“Successful demonstration of the technology could result in additional lightweight aggregate manufacturing facilities throughout the United States. Additional environmental benefits from widespread implementation of this technology could be a reduction of landfilling of FGD waste products as well as a reduction in the impacts from mining associated with conventionally – produced, expanded clay/shale – based, lightweight aggregates.”

6.2 Waste Streams and Their Disposal

Processed SDA and bottom ash, not used to manufacture aggregate will continue to be beneficially utilized as “alternate daily cover” in local landfill operations. This activity is permitted under Virginia’s Beneficial Use Regulations.

Stormwater

As previously noted the facility is subject to the Virginia Department of Environmental Quality (DEQ) General Virginia Pollutant Discharge Elimination System (VPDES) Permit regulations for Discharges of Storm Water Associated With Industrial Activity (9 VAC 25-151-10). The Standard Industrial Code (SIC) for the UA plant is 3295 Stone, Clay, Glass, and Concrete Manufactured Products. UA will obtain a VPDES permit for the plant that will specify effluent limitations; maintenance, monitoring and reporting requirements; and preparation of a stormwater pollution prevention plan.

A temporary Storm Water Permit and Pollution Prevention Plan was issued to the project during construction.

After construction, the manufactured aggregate plant received an operating permit for “Industrial Activity Storm Water Permit“ within the “Storm Water Pollution Prevention Plan”.

Wastewater

See previous Section 2.3 regarding details for Septic system wastewater.

Fugitive Dust Prevention:

Best management practice involves daily inspection of all filter fabric baghouses and bin vents. Inspections are logged. Cleaning and filter replacements are performed as required. Operating crews are trained in proper operation, maintenance and upkeep.

All raw SDA feedstock into the plant passes through F –120 Daybin. Binvent upgrades were required at this point to effectively control excess air during ash transfer. Binvents on storage silos F – 250 (Recycle Day Bin) and F – 210 (Additive silo) have performed adequately according to design. An appropriate sized, filter fabric baghouse (#BH – 410) was added at the curing vessel discharge to prevent fugitive dust within the lower confines of the curing vessel building.

In addition, proper bin venting was included with the installation of the new surge hopper within the curing vessel recirculation loop.

During curing vessel operation it was found that the ventilation of excess air upon charging the vessel was improperly designed. Even after attempts to slow air movement through the scrubber, the air velocity and volume was too high, and found to be the major contributor to moisture condensation in the curing vessel. In addition to an improper balance of air volume and velocity, fine particulate material would consistently plug water flow from the scrubber tank. After months of labor intensive curing vessel operation and observations, and cleaning, the proper dry, filter fabric, bin ventilation was designed and installed to replace the wet scrubber system. An air heater was also employed to prevent condensation from forming upon the curing vessel charging system.

Upon charging and discharging the curing vessel, a very unique conveyor system was employed to protect the materials from the elements, and again prevent potential fugitive dust emissions. The conveyor system employed is a “multi–fold” belt system that actually folds overtop of the belt contents, to cover the extruded materials and cured aggregates.

The entire crushing and screening circuit comprises enclosed components that vent through baghouse # BH –550. Upon final sizing of the aggregate, all aggregate passing the 16 mesh (TBC) sieve, passes through a gravimetric air classifier. In this way, any excess fine aggregate (-100 mesh) is removed from the product, returned back to the “recycle” circuit, and fed back through the process, with the raw materials in the manufacture of extruded products. Water spray application is incorporated directly after screening to reduce potential for airborne dust while stockpiling.

The stockpile and truck loading area, and haul road are paved to minimize fugitive dust. This area is properly maintained by water spray and sweeping, as required. A record is maintained to verify visual observations and document preventive upkeep (“Fugitive Dust Action Plan”).

6.3 Additional Environmental Benefits

Since Universal Aggregates' process does not require a combustion source, No combustion-related emissions are generated from the process.

The heat required in the curing step is generated from the exothermic reactions between the components of the embedding material, and the water used to mix the SDA and to form the extrudate. The curing vessel controls the reactions in terms of time, temperature and humidity. The temperature required in Universal Aggregates' process is below 200 ^{0}F.

Common practice in pyro-processes, a great deal of heat is required and generated by burning fossil fuels. The 2,000 ^{0}F temperatures burn off carboniferous materials and oxidize reactive minerals to create a porous void structure within the shale, slate or clay.

On the contrary, Universal Aggregates' process creates a considerable volume of internal pores due to the particle shape and particle packing characteristics in forming the extruded mass. Once the curing is complete, water reactions are completed, some evaporation occurs resulting in an intricate micro-pore structure within the manufactured aggregate product. Along with a relatively lower specific gravity, these internal voids provide attractive lightweight properties, improved thermal performance and acoustic performance within concrete masonry products.

Universal Aggregates' process consumes various coal combustion products (industrial by-product materials) as a source of raw feedstock. This beneficial aspect of the process reduces stress on environmental systems by reducing or eliminating the need for landfill disposal therefore reducing the detrimental impacts associated with land disposal, and the mining of raw materials.

7.0 ECONOMICS

7.1 Economic Parameters

Cost Data

The cost data included in this section includes all capital and operating costs from January 1, 2002, through December 31, 2006.

These costs consist of: engineering, professional services and testing, site development, excavation, foundations, structural steel, electric, insulation, mechanical and equipment, general contractor and subcontractors including all G&A, consumables, permits, insurance, and profit.

The operating costs include all labor, power, water, steam, home office costs, maintenance, inventory, additives and consumables.

The first of the following tables depicts Universal Aggregates, LLC “Total Project Recap” and is a total project recap that includes all of the project’s participants as a combined total. The four tables afterwards provide a Total Project Recap for each, separate project participant.

The original, total project cost was estimated at $19,581,734.00, and was scheduled for a thirty -month period, including start-up. As the report describes, three time extensions were provided to the project with no adjustment in financial contribution by the Department of Energy. Universal Aggregates LLC used the three time extensions for plant start-up, equipment modifications, and plant operations. All additional costs were borne by Universal Aggregates LLC to achieve commercial production.

Universal Aggregates, LLC Total Project Recap
1020 Lebanon Road
West Mifflin, PA 15122

DOE Cooperative Agreement # DE-FC26- 02NT41421

Period of performance covered by this billing 1/1/2002 to 12/31/06

Cost description	Claimed for this billing Period	Cumulative claimed Life to date
Wages		$ 4,609,870.00
Benefits & Taxes		$ 982,544.00
Travel		$ 221,800.00
Consultants		$ 5,126,402.00
Other		$ 7,252,528.00
Insurance		$ 54,981.00
Equipment		$ 7,431,238.00
Total Direct Cost		$ 25,679,363.00
G & A		$ 4,647,748.00
Total Cost		$ 30,327,111.00
Universal Aggregates		$ 23,103,111.00
Department of Energy		$ 7,224,000.00

P. J. Dick Incorporated

DOE Cooperative Agreement # DE-FC26- 02NT41421

Period of performance covered by this billing 1/1/2002 to 12/31/06

Cost description	Claimed for this billing Period	Cumulative claimed through this billing period
Wages		$ 371,173.00
Benefits & Taxes		
Travel		$ 24,222.00
Consultants		$ 4,531,914.00
Other		$ 59,422.00
Equipment		$ 4,625,811.00
Miscellaneous		
Total Direct Cost		$ 9,612,542.00
G & A		$ 395,799.00
Total Cost		$ 10,008,341.00
Universal Aggregates -		$ 5,047,592.00
Department of Energy -		$ 4,960,749.00

Consol Energy Inc

DOE Cooperative Agreement # DE-FC26- 02NT41421

Period of performance covered by this billing 1/1/2002 to 12/31/06

Cost description	Claimed for this billing Period	Cumulative claimed life to date
Wages		$ 208,946.00
Benefits & Taxes		$ 106,468.00
Travel		$ 24,596.00
Consultants		$ 6,559.00
Other		
Equipment		
Total Direct Cost	$ -	$ 346,569.00
G & A		$ 160,895.00
Total Cost	$ -	$ 507,464.00
Universal Aggregates - 87.4%		$ 334,172.00
Department of Energy - 12.6%	$ -	$ 173,292.00

SynAggs LLC
300 Bursca Drive, Suite 303
Bridgeville, Pa. 15017

DOE Cooperative Agreement # DE-FC26- 02NT41421

Period of performance covered by this billing 1/1/2002 to 12/31/06

Cost description	Claimed for this billing Period	Cumulative claimed through this billing period
Wages	$ -	$ 50,708.39
Benefits & Taxes	$ -	$ 7,222.61
Travel	$ -	$ 3,825.35
Consultants	$ -	$ 1,511.41
Other	$ -	$ 199.40
	$ -	
Equipment	$ -	
Total Direct Cost	$ -	$ 63,467.16
G & A		
Total Cost	$ -	$ 63,467.16
Universal Aggregates LLC - 50%	$ -	$ 31,733.00
Department of Energy - 50%	$ -	$ 31,734.00

Universal Aggregates, LLC
1020 Lebanon Road
West Mifflin, PA 15122

DOE Cooperative Agreement # DE-FC26- 02NT41421

Period of performance covered by this billing 1/1/2002 to 12/31/2006

Cost description	Claimed for this billing Period	Cumulative claimed Life to date
Wages		$ 3,979,043.00
Benefits & Taxes		$ 868,853.00
Travel		$ 169,157.00
Consultants		$ 586,418.00
Other		$ 7,192,906.00
Insurance		$ 54,981.00
Equipment		$ 2,805,427.00
Total Direct Cost		$ 15,656,785.00
G & A		$ 4,091,054.00
Total Cost		$ 19,747,839.00
Universal Aggregates - 87.4 %		$ 17,689,614.00
Department of Energy - 12.6 %		$ 2,058,225.00

7.2 Summary of Economic Performance and The Effects of Variables on Economic performance

This written summary presents projected performance based upon actual capital costs to date, actual material costs, and expenses, using estimates for production variables and current cost factors.

The estimated operating budget forecast for calendar year 2007 was established upon the current aggregate production capacity, which establishes 72,000 tons of lightweight aggregate produced and sold for the calendar year.

This projected performance is based primarily upon estimated annual production at approximately 50% of the design operating capacity, and the corresponding lightweight aggregate sales from that production.

A sensitivity analysis was calculated for cost based performance at three annual production forecast cases (96,000 tons, 120,000 tons, and 144,000 tons).

In all forecast cases, product sales income per ton of lightweight aggregate sold remained constant. Typically, adjustments in sales income would apply annually as based upon CPI index values, at a minimum.

In all forecast cases, the operating labor costs remained constant due to the full complement of hourly and salary labor required to operate the plant daily, regardless of production rate. However, the associated premium time labor costs, and the associated labor benefits, and equipment maintenance costs were all estimated to escalate slightly in conjunction with each increase in aggregate production.

In the variable cost category power, water steam and fuel were estimated based upon actual operating experience to date, using actual contract rates. Costs for consumables such as additives and reagents increase proportionately with aggregate production. On the other hand, costs associated with waste disposal and trucking are greatly reduced, or eliminated as aggregate production increases toward full production capacity.
The costs associated with overhead, leases, equipment rentals, non-cash depreciation, and salary management wages are estimated to remain constant throughout each forecast case.

In conclusion, the projected economic performance estimates indicate that the demonstration project must operate at, or very near full production capacity to experience a positive, net cash flow.

Future operating experience will undoubtedly be required to normalize operating and maintenance costs.

In tracking costs, UA will establish and refine routine operations and maintenance protocol, which will accurately establish future forecast performance estimates, and future operating budgets.

For the purposes of the previously described cost analyses, and effects upon economics, no cost savings over the actual disposal option were either assigned or implied for the host utility generator. The costs analysis was strictly from the perspective of a stand alone manufacturing enterprise.

Costs for future, subsequent plants must be derived on a site- by- site basis. Although installed capital costs and operating costs could be factored from current experience for modeling purposes, firm prices for capital equipment, construction, materials, engineering, and permits would be required for any future, subsequent plant installation. Cost analyses would also require a good understanding of the regional product market, and complete income structure.

8.0 COMMERCIALIZATION POTENTIAL AND PLANS

8.1 Market Analysis

(1) Product Market

The immediate geographical market area for the Birchwood manufacturing plant extends from greater metropolitan Washington, D.C., and south towards Norfolk, Virginia. This area covers over 11,000 sq. miles. In addition, parts of Delaware, Maryland, and the Virginia eastern shore provide market potential for Universal Aggregates. Fifteen concrete masonry production plants operate within this described immediate market area. The annual consumption of lightweight aggregates within the previously described market area is relatively steady at 400,000 tons. A strong, steady construction market exists from the greater Baltimore, Md./ Washington, D.C. corridor, and South through Richmond, Va., and on towards Chesapeake, Va. The demand for all basic construction materials, including lightweight aggregate is estimated to remain steady, if not increase slightly. Residential and commercial development is expected to remain strong in future years. The resultant demand for concrete masonry products consumes much of the lightweight aggregate market share. Extended market areas exist just west of the Birchwood plant, and north along Interstate 81 into Northern Maryland, and South central Pennsylvania. With the possibility of rail transportation, this extended market area provides access to an additional thirteen concrete masonry production plants, and up to 200,000 tons of lightweight aggregate consumption annually.

Additional lightweight aggregate market potential exists for lightweight structural concrete, and within geotechnical applications for lightweight structural embankments. The demand within these markets varies annually between 50,000 tons and 150,000 tons due to annual fluctuations in the demand for high– rise, multi–level building construction, bridge construction and rehabilitation, and highway construction activities.

(2) Availability of Feedstock

SDA from the Birchwood Power Station is an excellent source of raw feedstock materials for the Universal Aggregates' process. By design, 115,000 tons of SDA can be generated from the Birchwood Power Station annually. This raw feedstock material is sufficient to produce approximately 150,000 tons of manufactured lightweight aggregate.

Universal Aggregates' manufacturing facility is directly attached to the power station's ash silo via pneumatic transfer pipeline. SDA is transferred from the power station and into Universal Aggregates plant as required by the process controls. Universal Aggregates' manufacturing plant was designed to consume 100% of the Birchwood Power Station's SDA production.

8.1.1 Applicability of the Technology

Cost to Estimate the Potential Market for the Technology

With the success of the Pilot plant operations (1998 thru 2001) and the formation of Universal Aggregates LLC, in January of 2000, many manhours have been dedicated to evaluate the market potential for the manufactured, lightweight aggregate technology. At least 50 various coal combustion products including spray dryer ash, wet flue gas desulfurization materials, pulverized coal fly ash, and fluidized bed combustion ash have been evaluated and tested. At least twelve various sources of ash have been tested in pilot plant operations to evaluate the feasibility of continuous, 24 hour per day and seven–day per week operations. Lightweight aggregates from the various pilot plant operations were submitted to several commercial concrete masonry producers in six different states. Successful production of concrete masonry resulted from each of the various demonstrations, with a genuine interest in Universal Aggregates' product.

Universal Aggregates has conducted several regional market investigations to confirm market demand for the lightweight aggregate products, competition, and price structure. Of course not every coal–fired, electric utility boiler or scrubber would be located within an attractive lightweight aggregate market region.
From 1999 through 2003, this total combined effort cost approximately $2MM annually in testing, analytical investigation, product demonstrations, pilot plant operations, market investigation, the development of full–scale commercial plant design and financial modeling, including preliminary discussions with electric utility representatives, and potential lightweight aggregate customers. Where the appropriate market conditions exist, Universal Aggregates LLC will perform the necessary due diligence to expand the commercial deployment of the manufactured aggregate technology.

8.1.2 Market Size

Two fundamental markets are required to qualify and apply the technology; the "Process" market/ash generator must be genuinely committed to the alternative to disposal, and must have reasonable benefit. In addition, a developed, end use "Product" market must be present, and willing to receive the manufactured product at an acceptable market price.

Both of these driving mechanisms must preside separately upon economic merit recognized by each perspective industry, and in addition, both must mutually coexist in support of the other.

Entering the Market

Prior to plant construction at Birchwood, all of Universal Aggregate's manufacturing capacity for ASTM C-331, lightweight aggregate was pre–sold under contract to a local market broker. The exclusive purchasing agreement was contracted for an initial period of two years, with a re-opener clause for annual price adjustment, and time extension.

After considerable bench–scale testing, and during contract negotiations with Birchwood Power Station, Universal Aggregates' conducted three separate "Pilot Plant" runs using the Birchwood Station's spray dryer ash. The aggregates produced from these runs were utilized to test the aggregate performance, and engage potential customers in the Maryland/Virginia marketplace. Concrete masonry was produced with two concrete masonry companies, at two separate manufacturing plants on a commercial scale. These commercial demonstrations were also repeated. In addition, concrete masonry was also produced at a small test facility located at the National Concrete Masonry Association (NCMA) in Herndon, Virginia. The test facility demonstrated the ability to manufacture concrete masonry at a small scale with reliable comparison to actual commercial–scale production. The test facility was then utilized to produce concrete masonry with other potential customers in the region, without interrupting commercial production operations.

Both forms of testing proved very successful in terms of testing actual performance of the masonry unit, and in testing potential market acceptance.

In total, Universal Aggregates manufactured lightweight aggregates from Pilot Plant operations using two sources of spray dryer ash, five sources of wet FGD scrubber waste, and five sources of pulverized-coal fly ash.

This strategy of product introduction and performance testing was undertaken with twelve various concrete masonry producers in six states.

8.1.3 Market Barriers

The Pilot Plant activity described in the previous section is necessary to understand the preparatory work and strategy taken to assure both technical merit and establish confidence to the lenders that the end market would be willing to purchase the aggregate products with an acceptable rate of return. This marketing activity was necessary to be established well in advance of plant construction.

With Universal Aggregates' “new“ manufacturing technology, the DOE's PPII program was very helpful in supporting the technical merit, and financial partnering assistance for the project to move ahead. The success of the commercial demonstration at Birchwood will provide the example for future installations of Universal Aggregates' technology at other host utility sites.

Potential Market Barriers

- Geographic limitations to regionally established, lightweight aggregate markets.
- Relative offset disposal expense (too low to justify investment).
- Time and resources required to establish future commercial installations.
- Lack of, or elimination of effective beneficial use regulations.
- Lack of interest for financial investment (manufacturing, and risk of new technology).
- Availability of reasonably priced reagents for curing process.
- Availability of property adjacent to source of feedstock for plant construction and aggregate stockpile yard area (6 – 10 acres).
- Quality of ash/FGD feedstock materials.

8.1.4 Economic Comparison with Competing Technologies

Competing Materials

The primary lightweight aggregate market within the geographical market area is dominated by expanded shale (approx. 66%). Imported Greek Pumice comprises approximately 18% of the regional lightweight aggregate market. Bottom ash comprises approximately 12% of the regional lightweight aggregate market, and expanded slate approximately 4%.

Nationwide, fuel consumption is a major cost in the production of kiln–expanded lightweight aggregates (clay, shale and slate). Temperatures are required to reach the 2,000 ^{0}F mark to effectively “expand” the aggregates, and produce the desired bulk unit weight.

Foreign imports such as Pumice are also subject to increasing freight charges due to the increasing cost of fuel for transportation in ocean–going vessels, and commonly subject to double handling in many cases for distribution into the market.

Universal Aggregates LLC’s technology employs a proprietary, and very moderate temperature process to cure the aggregate. Throughout the curing cycle, a curing temperature below 200 ^{0}F is maintained in an adiabatic condition. A curing vessel, specifically designed for the process, controls process time, temperature and moisture. No combustion source is required.

Marketing evaluations, product testing, and current sales indicate that Universal Aggregates’ can provide an attractive product into this established lightweight aggregate market, and be competitive.

8.2 Commercialization Plans

Future Plans (potential market)

In general, Universal Aggregates’ market research located many potential sources of raw feedstock materials. Practically speaking, of course not all of these potential sources of raw feedstock materials fit the business model.

For example, basic supply/demand economics prevail in that an end product market must be reasonably accessible, at a competitive price. If the product market is geographically available, a minimum supply of quality feedstock materials must be available to justify the financial investment with the required rate of return.

A potential “host” utility must also be willing to evaluate the cost benefit associated with a beneficial, end use process in lieu of the disposal option.
For handling efficiency, the aggregate manufacturing plant should be attached directly to the feedstock source, and a minimum footprint available (6 to 10 acres) for construction of the manufacturing facility and the required stockpile capacity for the given market.

The reagents required for the curing stage must be available at a reasonably acceptable cost.

With these fundamental issues addressed, Universal Aggregates LLC remains very engaged to expand the commercial deployment of the manufactured aggregate technology. Universal Aggregates LLC is interested in the design and construction of aggregate manufacturing facilities. The company is integrated within the heavy construction trades, and has the capability to design, build, operate, manage daily business, and market the end products of these manufacturing facilities. Universal Aggregates LLC will entertain the potential for partnerships, licensing arrangements, and marketing brokers.

With the Birchwood project in place and operational, Universal Aggregates LLC is planning a strategic advertisement and PR campaign. This effort is intended to introduce the technology and attract potential investors, partners, and potential host utility sites.

The commercial reality of the Birchwood site provides the tangible evidence that the technology is viable. This provides potential lenders, partners and customers the basis to make potential investment decisions. The PPII program was beneficial in accelerating the initial commercial demonstration of the technology.

With the commercial demonstration technology developed to date, and with the current product market conditions, UA would require 100,000 tons of raw feedstock annually, as a minimum, to qualify future host utility sources. This fundamental aspect of the economic model could very well change in the future with increasing fuel costs, increasing demand for lightweight aggregates, and process improvements from technology development.

Universal Aggregates maintains a home office and a laboratory in West Mifflin, Pa. Technical merit for any potential facility can be evaluated, the business model tested, and the specific product market fully explored to insure potential success.

The experience derived from the Birchwood demonstration will undoubtedly improve the design, engineering, start–up and operation of future endeavors.

Universal Aggregates LLC is currently seeking both financial partners and operating partners for the Birchwood manufacturing site, and future facilities.

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions from Commercial Demonstration

1. The manufactured aggregate plant successfully demonstrated the continuous and fully integrated process operation including mixing, extrusion, curing, crushing and screening. Lightweight aggregates with proper size gradation and bulk density were produced from SDA for use in production of concrete masonry units.

2. Modifications of mixing and extrusion equipment were necessary to address thioxotropic properties of SDA for processing.

3. Sufficient capacity of mixing equipment is crucial to achieve material balance for continuous aggregate production and improved aggregate quality.

4. The curing vessel, which was designed for the large-scale commercial application, was successfully operated in a mass flow mode and performed well after modifications.

5. Modifications of material handing and transfer equipment were necessary to optimize "off–the–shelf" equipment to achieve desired performance for continuous aggregate production.

6. Pilot plant experience was necessary to establish the fundamental basis for engineering, design and marketing for the commercial demonstration.

7. "Hands on" experience of UA team members and of specialized equipment vendors and manufacturers was required for the success of the commercial demonstration.

8. UA team members have identified the critical components required for commercial scale success. Future deployment of the technology will benefit from this demonstration.

9. To be completely successful as a profitable, commercial business venture, UA will be required to engage additional host utility sites, within developed end-product market regions. The potential to diversify the technology should also be developed to expand potential business opportunities.

9.2 Recommendations

1. It is recommended to establish normalized operating and maintenance costs after continued long-term operation of the manufactured aggregate plant. The costs will be used to determine economic feasibility for aggregate production at other utility sites.

2. The manufactured aggregate process was successfully demonstrated that aggregates can be commercially produced from SDA. It is recommended that application of this technology be extended to other coal combustion by-products including wet FGD and FBC materials at utility power plants, if it is economically feasible.

3. It is recommended that USDOE work with UA to develop the future commercial potential of the “manufactured aggregate” process technology.

Bibliography of Other Project Reports

Quarterly Technical Reports

Dec. 31, 2002
Mar. 31, 2003
Jun. 30, 2003
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Topical Reports (Public Design Report)

No.1, April, 2003
No. 2, Oct., 2003
Addendum to Topical Report No. 2, Appendix “C”, Oct., 2005

Report of Termination, or Completion Inventory (580.1 – 9, SF 120)
Submitted March 2007

TABLE 1 PLANT OPERATION SUMMARY

April 2004	Began startup operation in the manufactured aggregate plant.
June 2004	Took over complete ash processing and disposal responsibilities from Birchwood Power Plant.
September 2004	Reached continuous extrusion operation at low capacity factors for short periods of time.
October 2004	Charged the curing vessel with green extrudates at low capacity factors for short periods of time.
December 2004	Initiated full-integrated process operation for aggregate production at low capacity factors for short periods of time. Produced about 580 tons of crushed aggregates and sold crushed aggregate to a masonry producer in production of concrete masonry units.
April 2005	Emptied curing vessel due to rat hole problems. The curing vessel designer inspected the empty curing vessel.
May 2005	Installed new rotary distribution chute for better curing vessel charge. Modified pugmill, pugsealer and extruder to improve extrusion operation during Birchwood Power Plant outage.
July 2005	Completed refill of curing vessel and confirmed operation of the curing vessel new rotary distribution chute.
August 2005	Conducted tests to examine velocity profiles to achieve uniform or near uniform flow of feed charge in curing vessel. The curing vessel designer participated in the testing and recommended curing vessel operation conditions. Resumed curing vessel charge on August 26.

September 2005	Produced about 1,500 tons of crushed aggregate. Equipment and operational problems still limited aggregate production and impede plant availability.
October 2005	The management team was replaced with focus on identifying and evaluating problem areas of the plant. Initiated discussions with relevant vendors and engineering firms regarding problem areas
November 2005	Operated the front end of the plant (pugmill/extruder) at improved capacity and reliability
December 2005	Achieved the DOE milestone of 24 hours continuous integrated operation for aggregate production
March 2006	Installed a new bin vent dust collector to address the excess air problem in SDA day bin.
May 2006	Operated the new curing vessel recirculation system for improvement of curing vessel operation. Cleared deposits in the curing vessel cans. Configured the slide gate at the base of SDA daybin to reduce intermittent ash flushing of weight feeder. Achieved a record single-day total SDA throughput for the processing plant (414 tons) on May 27.
June 2006	Curing vessel design engineer visited and advised the curing vessel operation conditions. Identified the causes of chunk formation problems in curing vessel. Started to empty curing vessel for further evaluation
July 2006	Obtained the internal measurement of curing vessel. Completed refilling and velocity profiling of curing vessel. Completed installation of 400 HP motor and variable speed drive for the pugsealer. Installed new water spray box and auxiliary spray nozzles. Completed modifications of the PLC control logic. Resumed aggregate production on July 25.
August 2006	Produced a record of about 3,000 tons of crushed aggregates. Identified insufficient incorporation of recycle in pugmill mixing as a major limitation for integrated operation of full aggregate production.

September 2006	Brought air-classifier on-line to establish the desired gradation of fines in aggregate products. Planned a custom-built twin shaft pugmill to replace existing single shaft pugmill for increased aggregate production. Birchwood Power Plant started scheduled outage on September 23. Emptied curing vessel and stockpiled cured extrudates for curing vessel recharge.
October 2006	Birchwood Power Plant continued scheduled outage. Completed removal of internal deposits in curing vessel. Installed adjustable flow dampers in curing vessel to improve curing vessel operation at the recommendation of the design engineer. Replaced and upgraded the rotary distributor for curing vessel charge. Held preliminary discussions with a vender on design of a new twin-shaft pugmill.
November 2006	Birchwood Power plant extended its scheduled outage most of the month. Recharged curing vessel and adjusted the new curing vessel flow dampers to achieve uniform velocity in each of the four cans. Curing vessel performed well after adjustment. Continued discussions with a vendor on the design details of the new twin-shaft pugmill. The plant resumed processing SDA on November 24.
December 2006	The new twin-shaft pugmill was constructed and inspected by UA engineers. It will be installed in January 2007 to improve the plant productivity and availability. Aggregate production totaled 1,276 tons.

TABLE 2 MATERIAL PROCESSING WITH LOW SDA THROUGHPUT AND RECYCLE AS A MIX COMPONENT DURING INTEGRATION RUNS

Extrudate Moisture, wt% dry	Mix Component, lb/hr				Embedding Material, lb/hr (c)	Recycle Production, lb/hr (d)	Curing Vessel Charge, lb/hr (e)	Curing Vessel Discharge, lb/hr (f)	Aggregate Production, lb/hr (g)
	SDA (a)	Recycle (b)	Water	Additive					
32	12000	0	3840	100	3935	5416	19925	19100	13684
32	12000	6000	4968	100	5767	7850	28835	27569	19715
32	12000	9113	5553	100	6692	9113	33458	31963	22850
32	16000	0	5120	100	5305	7270	26525	25423	18213
32	16000	8000	6624	100	7681	10455	38405	36715	26260
32	16000	12130	7400	100	8908	12130	44538	42545	30414
32	18000	0	5260	100	5965	8107	29825	28585	20478
32	18000	9000	7452	100	8638	11758	43190	41288	29531
32	18000	13639	8324	100	10016	13639	50079	47836	34197
30	12000	0	3600	125	3931	5347	19656	18918	13571
30	12000	6000	4620	125	5686	7746	28431	27290	19544
30	12000	8908	5114	125	6537	8908	32684	31348	22440
30	16000	0	4800	125	5231	7115	26156	25169	18055
30	16000	8000	6160	125	2571	10313	37856	36333	26020
30	16000	11854	6815	125	8699	11854	43493	41710	29857
30	18000	0	5400	125	5881	7999	29406	28295	20297
30	18000	9000	6930	125	8514	11597	42569	40854	29257
30	18000	13327	7666	125	9779	13327	48897	46892	33565
28	12000	0	3360	150	3878	5278	19388	18735	13458
28	12000	6000	4272	150	5606	7641	28028	27011	19370
28	12000	8708	4684	150	6385	8708	31927	30746	22038
28	16000	0	4480	150	5158	7019	25788	24916	17896

28	16000	8000	5696	150	7482	10171	37308	35950	25779
28	16000	11582	6240	150	6493	11582	42466	40890	29308
28	18000	0	5040	150	5798	7890	28988	28006	20115
28	18000	9000	6408	150	8390	11436	41948	40419	29983
28	18000	13020	7019	150	9547	13020	47736	45964	32944

(a) SDA from K-120A (b) Recycle from K-250 (c) Embedding material from L-320 (d) Recycle production from L-250C
(e) Curing vessel charge from L-410A (f) Curing vessel discharge from L-410F (g) Crushed aggregates from L-510C

TABLE 3   MATERIAL PROCESSING WITH HIGH SDA THROUGHPUT AND RECYCLE AS A MIX COMPONENT DURING INTEGRATION RUNS

Extrudate Moisture, wt% dry	Mix Component, lb/hr				Embedding Material, lb/hr (c)	Recycle Production, lb/hr (d)	Curing Vessel Charge, lb/hr (e)	Curing Vessel Discharge, lb/hr (f)	Aggregate Production, lb/hr (g)
	SDA (a)	Recycle (b)	Water	Additive					
32	20000	0	6400	150	6638	9021	33188	31812	22791
32	20000	10000	8280	150	9608	13077	48038	45929	32849
32	20000	15128	9253	150	11145	15128	55727	53235	38057
32	25000	0	8000	175	8294	11272	41469	39748	28476
32	25000	12500	10350	175	12006	16342	60031	57392	41050
32	25000	18964	11565	175	13926	18964	69630	66516	47551
32	30000	0	9600	200	9950	13523	49750	47685	34162
32	30000	15000	12420	200	14405	19607	72025	68857	49250
32	30000	22751	13877	200	16707	22751	83535	79798	57046
30	20000	0	6000	150	6538	8891	32688	31454	22563
30	20000	10000	7700	150	9463	12889	47313	45408	32519
30	20000	14814	8518	150	10871	14814	54353	52125	37311
30	25000	0	7500	175	8169	11110	40844	39301	28191
30	25000	12500	9625	175	11825	16107	59125	56743	40636
30	25000	18509	10647	175	13583	18509	67913	65128	46619
30	30000	0	9000	200	9800	13328	49000	47148	33820
30	30000	15000	11550	200	14188	19325	70938	68079	48754
30	30000	22206	12775	200	16285	22206	81476	78134	55928
28	20000	0	5600	150	6438	8761	32188	31096	22335
28	20000	10000	7120	150	9318	12701	46588	44889	32188
28	20000	14456	7797	150	10601	14456	53004	51035	36579

28	25000	0	7000	175	8044	10947	40219	38854	27906
28	25000	12500	8900	175	11644	15872	58219	56095	40223
28	25000	18064	9746	175	13246	18064	66231	63769	45705
28	30000	0	8400	200	9650	13134	48250	46612	33478
28	30000	15000	10680	200	13970	19043	69850	67301	48258
28	30000	21670	11694	200	15891	21670	79455	76500	54830

(a) SDA from K-120A (b) Recycle from K-250 (c) Embedding material from L-320 (d) Recycle production from L-250C
(e) Curing vessel charge from L-410A (f) Curing vessel discharge from L-410F (g) Crushed aggregates from L-510C

TABLE 4 AVERAGE MONTHLY HYDRATED LIME CONTENT AND MONTHLY RANGES OF CARBON CONTENTS IN SDA

Month	Hydrated Lime Content, wt%	Carbon Content, wt%
June, 2004	27.66 ± 0.63	ND
July, 2004	24.71 ± 1.81	ND
August, 2004	28.63 ± 1.68	ND
September, 2004	26.41 ± 2.26	ND
October, 2004,	21.95 ± 2.26	ND
November, 2004	21.59 ± 1.14	ND
December, 2004	21.65 ± 1.20	ND
January, 2005	20.85 ± 1.70	3.9 – 4.5
February, 2005	20.73 ± 1.20	4.5 – 6.2
March, 2005	21.85 ± 1.00	3.9 – 6.2
April, 2005	16.92 ± 5.47	3.9 – 6.2
May, 2005	13.21 ± 1.98	3.9 – 6.2
June, 2005	10.78 ± 1.90	3.9 – 4.5
July, 2005	9.31 ± 0.93	3.9 – 5.3
August, 2005	11.34 ± 2.41	3.9 – 6.2^{+}
September, 2005	12.97 ± 1.81	3.9 – 4.5
October, 2005	11.46 ± 2.37	3.9 – 5.0
November, 2005	13.94 ± 2.39	3.9 – 6.2
December, 2005	18.61 ± 1.10	3.9 – 5.3
January, 2006	16.75 ±2.38	3.9^{-} – 6.2
February, 2006	16.46 ± 2.34	3.9 – 4.5
March, 2006	12.84 ± 2.88	3.9 – 6.2
April, 2006	11.71 ± 3.17	3.9 – 6.2
May, 2006	8.86 ± 2.63	3.9 – 6.2^{+}
June, 2006	9.80 ± 1.49	4.5 – 6.2^{+}
July, 2006	9.79 ± 3.74	3.9 – 6.2
August, 2006	13.35 ± 4.29	3.9 – 6.2
September, 2006	10.67 ± 4.07	3.9 – 6.2^{+}
December, 2006	19.05 ± 2.11	3.9 – 6.2^{+}

ND represents not determined

TABLE 5 ANALYSES OF BIRCHWOOD SPRAY DRYER ASH

Sampling Date	9/16/04	10/28/04	11/9/04	1/26/05	4/7/05	6/24/05	7/21/05	8/4/05	9/21/05	10/21/05	12/9/05	1/25/06	2/23/06	3/7/06	4/21/06	5/12/06	7/7/06	8/7/06	12/13/06
Moisture, wt% (as-rec.)	1.20	1.59	1.39	1.53	1.36	1.06	1.02	1.12	0.70	1.00	1.53	0.90	0.43	0.61	1.12	1.20	0.98	0.64	1.08
Ultimate Analysis, wt% (dry)																			
Carbon	5.50	3.94	4.66	4.54	5.16	4.16	5.37	6.24	5.40	4.53	4.61	2.75	4.01	4.43	6.34	7.15	4.91	8.14	7.25
Hydrogen	0.06	0.42	0.27	0.00	0.82	0.28	0.18	0.01	0.26	0.74	0.30	0.70	0.68	0.55	0.42	0.36	0.09	0.12	0.62
Nitrogen	0.31	0.23	0.24	0.02	0.10	0.02	0.04	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.08	0.01	0.05	0.03
Sulfur	3.56	3.58	3.58	3.41	3.19	3.65	3.80	4.81	3.51	3.08	3.97	4.26	3.86	3.50	4.59	5.67	4.23	3.47	3.92
Ash (750 C)	86.23	89.29	89.18	89.26	89.73	92.30	91.47	90.56	91.23	91.32	86.25	91.34	90.69	90.83	89.92	90.35	90.43	86.33	87.44
Major Element (a), wt% (dry)																			
SiO_2	26.46	28.73	30.25	30.29	33.71	36.79	36.83	36.46	39.65	37.19	31.78	31.74	32.76	36.73	32.68	36.13	34.43	33.61	32.59
Al_2O_3	15.20	15.46	16.86	16.51	17.07	18.20	18.71	19.80	18.46	18.32	14.99	16.45	19.07	19.26	19.35	20.20	17.42	15.65	16.72
TiO_2	0.64	0.76	0.80	0.74	0.83	0.87	0.91	0.91	1.03	0.97	0.78	0.84	0.88	0.98	0.79	0.92	0.96	1.12	0.82
Fe_2O_3	1.76	2.24	2.19	1.98	1.71	1.84	1.90	2.85	1.95	1.71	2.31	3.33	2.50	1.79	2.61	3.09	3.01	2.22	2.72
CaO	34.39	29.36	26.75	28.63	24.97	18.63	18.07	20.63	17.48	18.84	24.79	25.95	23.11	20.40	20.52	15.75	20.09	21.53	24.53
MgO	0.82	0.70	0.73	0.77	0.69	0.89	0.70	0.73	0.75	0.74	0.71	0.67	0.71	0.80	0.84	0.76	0.78	0.85	0.81
Na_2O	0.14	0.19	0.23	0.14	0.17	0.20	0.19	0.18	0.21	0.19	0.15	0.16	0.17	0.18	0.21	0.33	0.19	0.18	0.30
K_2O	0.87	1.43	1.44	1.16	1.68	2.05	1.68	1.50	1.87	1.95	1.40	1.42	1.44	1.93	1.56	1.60	1.59	1.85	1.65
P_2O_3	0.09	0.07	0.08	0.04	0.08	0.00	0.01	0.04	0.05	0.04	0.11	0.06	0.08	0.05	0.32	0.37	0.06	0.06	0.12
SO_3	8.91	8.94	8.96	8.52	7.87	9.13	9.49	12.02	8.77	7.70	9.92	11.04	9.60	8.85	11.49	12.76	10.58	8.69	9.79
Unaccounted	10.72	12.12	11.71	11.22	11.10	11.40	11.50	4.88	9.78	12.35	13.06	8.34	9.68	9.03	9.63	8.09	10.89	14.24	9.95
Major Compound, wt%																			
$Ca(OH)_2$	28.9	24.0	21.0	20.4	20.9	11.7	9.3	8.8	10.5	13.2	19.4	17.9	16.2	12.5	11.0	4.6	10.2	16.6	17.6
$SiO_2+Al_2O_3+Fe_2O_3$	43.42	46.43	49.30	48.78	52.49	56.83	57.44	59.11	60.06	57.22	49.08	52.52	54.33	57.78	54.64	59.42	54.86	51.48	52.03
Calcium Utilization, % (b)	18.1	21.2	23.4	20.8	22.4	34.3	36.8	40.8	35.5	28.6	27.7	28.7	29.2	30.0	39.1	62.9	36.9	28.3	27.9

(a) Calculation of major elements reported in oxide formBased on molar ratios of sulfur to calcium contents in spray dryer ash

TABLE 6 MATERIAL PROCESSING AND AGGREGATE PRODUCTION WITH RECYCLE AS A MIX COMPONENT

Mix Components, lb/hr									
SDA (K120A)	20000	20000	20000	20000	20000	20000	20000	20000	20000
Water	6400	6776	7152	7528	7904	8280	8656	9032	9253
Recycle	0	2000	4000	6000	8000	10000	12000	14000	15178
Additive#2	150	150	150	150	150	150	150	150	150
Embedding Material, lb/hr									
Additive #1	1677	1827	1977	2127	2277	2427	2577	2727	2816
SDA (K120B)	4961	5976	5848	6292	6736	7180	7624	8068	8330
Total Embedding	6638	7232	7826	8420	9014	9608	10202	10796	11145
Spent Embedding. Material, lb/hr (1)	7822	8522	8522	9922	10621	11321	12021	12721	13134
Crushed Fines (2)	1200	1311	1311	1535	1645	1756	1867	1978	2044
Recycle produced, lb/hr (3)	9021	9832	9832	11465	12266	13077	13889	14700	15178
SDA Consumption, lb/hr	24961	25405	25848	26292	26736	27180	27624	28068	28330
SDA Consumption, ton/hr	12.48	12.70	12.92	13.15	13.37	13.59	13.81	14.03	14.16
Net recycle produced, lb/hr (4)	9021	7832	6644	5455	4266	3077	1889	700	0
Crushed Aggregate Production, lb/hr	22791	24802	26814	28826	30837	32849	34861	36873	38057
Crushed Aggregate Production, ton/hr	11.40	12.40	13.41	14.41	15.42	16.42	17.43	18.44	19.03

(1) Embedding material produced after processing in curing vessel
(2) 5% aggregates produced
(3) Combination of spent embedding material and crushed fines
(4) Difference between recycle produced from processing and used as a mix component

TABLE 7 TEST CONDITIONS AND RESULTS OF INTEGRATION RUNS FROM 8/2/06 TO 8/9/06

DATE	8/2/06	8/2/06	8/2/06	8/2/06	8/3/06	8/3/06	8/3/06	8/3/06	8/3/06	8/3/06	8/4/06	8/4/06	8/9/06	8/9/06	8/9/06	8/9/06
TIME	3:08 PM	4:01 PM	5:15 PM	6:23 PM	1:10 AM	1:30 PM	2:50 PM	4:10 PM	10:20 PM	11:20 PM	4:15 AM	6:00 AM	2:40 AM	3:55 AM	4:39 AM	5:25 AM
SAMPLE LOCATION	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top
TEST CONDITIONS																
Mix Components, lb/hr																
SDA (K120 A)	29,000	29,000	29,000	29,000	29,000	28,000	28,000	28,000	29,000	29,000	29,000	29,000	29,000	29,000	29,000	29,000
Water	9,450	9,450	9,450	9,450	9,450	10,100	10,100	10,100	9,600	9,650	9,650	9,650	10,650	9,830	9,830	9830
Additive	350	350	350	350	350	425	425	425	400	425	410	410	400	400	400	400
Recycle #2 (K250)	2,000	2,000	2,000	2,000	2,000	4,000	4,000	4,000	2,000	2,000	2,000	2,000	4,000	2,000	2,000	2,000
Embedding Material, lb/hr																
SDA (K120B)	7,644	7,644	7,644	7,644	7,644	7,881	7,881	7,881	7,644	7,644	7,644	7,644	8,126	7,644	7,644	7,644
Additive #1 (K210)	2,585	2,585	2,585	2,585	2,585	2,662	2,662	2,662	2,585	2,585	2,585	2,585	2,748	2,585	2,585	2,585
CV Top Materials (1)																
Ave. penetrometer reading	3.44	3.66	2.95	3.27	3.64	3.36	2.91	2.83	3.57	3.19	3.23	3.29	3.01	3.08	2.91	4.39
Temperature, deg. F	168.5	181.7	182.6	176.1	175.6	182.6	181.9	180.6	181.0	169.4	171.7	175.3	175.8	182.2	184.5	192.0
Moisture, wt% dry (2)	7.27	10.81	13.01	10.17	13.70	10.56	12.32	14.66	8.17	ND	17.53	16.84	15.83	10.96	7.76	7.55

(1) Blend of green extrudates and embedding material
(2) Moisture content of embedding material

TABLE 8 TEST CONDITIONS AND RESULTS OF INTEGRATION RUNS FROM 8/9/06 TO 8/11/06

DATE	8/9/06	8/9/06	8/9/06	8/9/06	8/9/06	8/9/06	8/10/06	8/10/06	8/10/06	8/11/06	8/11/06	8/11/06	8/11/06	8/11/06	8/11/06
TIME	5:15 PM	6:10 PM	8:00 PM	9:00 PM	10:00 PM	11:12 PM	2:20 PM	3:25 PM	5:15 PM	1:20 AM	2:20 AM	3:20 AM	6:05 AM	7:05 AM	1:50 PM
SAMPLE LOCATION	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top
TEST CONDITIONS															
Mix Components, lb/hr															
SDA (K120 A)	24,000	24,000	24,000	24,000	24,000	24,000	26,000	26,000	26,000	27,000	27,000	27,000	27,000	27,000	27,000
Water	9,700	9,700	9,750	9,750	9,750	9,750	9,675	9,675	9,675	9,700	9,700	9,700	9,700	9,700	9,700
Additive #2	450	450	475	475	475	475	400	450	450	475	475	475	475	475	475
Recycle (K250)	6,000	6,000	6,000	6,000	6,000	6,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Embedding Material, lb/hr															
SDA (K120B)	7,440	7,440	7440	7440	7440	7440	7440	7440	7440	7626	7626	7626	7626	7626	7626
Additive #1	2,516	2,516	2516	2516	2516	2516	2516	2516	2516	2580	2580	2580	2580	2580	2580
CV Top Materials (1)															
Ave. penetrometer reading	3.02	3.51	2.95	2.86	3.16	2.39	2.83	2.85	3.13	3.36	3.17	3.07	3.33	3.12	3.14
Temperature, degree F	179.2	191.4	190.0	184.4	167.6	184.3	164.3	183.6	171.8	161.6	163.9	167.7	184.0	171.1	167.2
Moisture, wt% dry (2)	5.06	7.38	12.58	14.07	12.87	13.43	8.13	7.21	10.94	16.00	14.25	14.70	15.74	15.09	7.33

(1) Blend of green extrudates and embedding material
(2) Moisture content of embedding material

TABLE 9 TEST CONDITIONS AND RESULTS OF INTEGRATION RUNS FROM 8/15/06 TO 8/18/06

DATE	8/15/06	8/15/06	8/15/06	8/15/06	8/15/06	8/15/06	8/15/06	8/15/06	8/15/06	8/15/06	8/17/06	8/17/06	8/17/06	8/18/06	8/18/06
TIME	2:45 AM	3:40 AM	6:13 AM	7:15 AM	8:08 AM	9:18 AM	5:27 PM	6:07 PM	6:37 PM	8:00 PM	7:40 PM	8:50 PM	10:51 PM	12:03 AM	2:00 AM
SAMPLE LOCATION	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	Cv top
TEST CONDITIONS															
Mix Components, lb/hr															
SDA (K120 A)	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000
Water	9,700	9,700	9,700	9,700	9,700	9,700	9,725	9,725	9,725	9,725	9,700	9,700	9,625	9,625	9,625
Additive #2	475	475	475	475	475	475	475	475	475	475	475	460	475	475	475
Recycle (K250)	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Embedding Material, lb/hr															
SDA (K120B)	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880
Additive #1 (K210)	2,664	2,664	2,664	2,664	2,664	2,664	2,664	2,664	2,664	2,664	2,664	2,664	2,664	2,664	2,664
CV Top Materials (1)															
Ave. penetrometer reading	3.12	2.76	3.15	2.69	3.07	3.45	2.84	2.53	2.25	2.30	2.85	3.05	3.20	2.76	2.56
Temperature, degree F	176.4	169.7	178.9	178.1	184.8	187.5	180.8	162.4	177.8	185.0	168.2	180.2	168.7	199.3	177.9
Moisture, wt% dry (2)	10.80	13.47	10.70	12.88	13.26	14.19	11.99	9.66	10.76	13.59	14.37	17.19	12.47	13.61	7.46

(1) Blend of green extrudates and embedding material
(2) Moisture content of embedding material

TABLE 10 TEST CONDITIONS AND RESULTS OF INTEGRATION RUNS FROM 8/22/06 TO 8/24/06

DATE	8/22/06	8/22/06	8/22/06	8/22/06	8/22/06	8/22/06	8/22/06	8/22/06	8/22/06	8/23/06	8/23/06	8/24/06	8/24/06	8/24/06	8/24/06
TIME	12:15 AM	1:10 AM	7:05 AM	9:14 AM	6:30 PM	8:00 PM	8:50 PM	9:50 PM	10:50 PM	6:55 PM	8:00 PM	5:00 AM	6:00 AM	4:15 PM	5:50 PM
SAMPLE LOCATION	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top
TEST CONDITIONS															
Mix Components, lb/hr															
SDA (K120 A)	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000
Water	10,100	10,100	10,100	10,125	10,100	10,150	10,125	10,125	10,125	10,225	10,225	10,225	10,225	10,120	10,120
Additive #2	375	375	375	375	325	325	350	350	335	410	410	410	410	410	410
Recycle (K250)	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Embedding Material, lb/hr															
SDA (K120B)	8,088	8,088	8,088	8,088	8,088	8,088	8,088	8,088	8,088	8,088	8,088	8,088	8,088	8,088	8,088
Additive #1 (K210)	2,437	2,437	2,437	2,437	2,437	2,437	2,437	2,437	2,437	2,437	2,437	2,437	2,437	2,437	2,437
CV Top Materials (1)															
Ave. penetrometer reading	3.41	3.40	3.25	3.34	2.78	3.07	3.12	3.00	3.15	2.79	3.06	3.00	2.86	4.51	2.81
Temperature, degree F	167.3	161.9	164.4	159.7	167.3	168.3	162.8	185.5	180.0	176.2	153.9	157.6	158.7	153.4	169.6
Moisture, wt% dry (2)	10.77	ND	14.08	17.52	8.41	11.51	12.47	10.02	12.17	14.16	13.57	15.19	12.26	12.81	12.28

(1) Blend of green extrudates and embedding material
(2) Moisture content of embedding material

TABLE 11 TEST CONDITIONS AND RESULTS OF INTEGRATION RUNS FROM 8/25/06 TO 8/30/06

DATE	8/25/06	8/25/06	8/25/06	8/25/06	8/25/06	8/26/06	8/26/06	8/26/06	8/26/06	8/28/06	8/28/06	8/28/06	8/29/06	8/29/06	8/30/06
TIME	4:15 AM	5:00 AM	6:43 AM	7:30 PM	8:30 PM	4:35 AM	5:30 AM	6:30 AM	7:20 AM	3:00 AM	3:40 AM	4:30 PM	1:40 AM	2:10 AM	7:35 AM
SAMPLE LOCATION	CV top	CV top	CV topp	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top
TEST CONDITIONS															
Mix Components, lb/hr															
SDA (K120 A)	26,000	26,000	26,000	26,000	26,000	25,600	25,400	25,200	25,200	22,400	22,900	26,000	26,000	26,000	28,000
Water	10,150	10,150	10,150	10,200	10,200	10,200	10,200	10,200	10,150	8,025	8,200	9,900	8,775	9,550	9,750
Additive#2	450	450	450	425	425	450	450	450	400	375	390	450	350	350	385
Recycle (K250)	6,000	6,000	6,000	6,000	6,000	6,400	6,600	6,800	7,000	2,000	2,250	4,000	2,000	4,000	2,000
Embedding Material, lb/hr															
SDA (K120B)	8,088	8,088	8,088	8,082	8,022	8,022	8,022	8,182	8,182	6,174	6,317	7,683	7,127	7,665	7,691
Additive #1 (K210)	2,437	2,437	2,437	2,437	2,437	2,437	2,437	2,432	2,437	2,088	2,137	2,315	2,148	2,310	2,318
CV Top Materials (1)															
Ave. penetrometer reading	3.37	3.49	3.04	3.10	2.97	3.07	3.01	3.22	3.52	3.47	3.49	2.85	3.04	3.06	2.84
Temperature, degree F	173.2	180.0	175.3	173.4	176.9	164.9	180.0	182.8	172.4	173.3	171.6	168.5	180.5	180.6	181.6
Moisture, wt% dry (2)	11.76	14.1	15.09	13.45	10.65	11.83	10.94	9.43	7.97	9.60	12.97	9.63	9.79	14.07	12.69

(1) Blend of green extrudates and embedding material
(2) Moisture content of embedding material

TABLE 12 TEST CONDITIONS AND RESULTS OF INTEGRATION RUNS ON 8/30/06 AND 8/31/06

DATE	8/30/06	8/30/06	8/30/06	8/30/06	8/31/06	8/31/06
TIME	8:35 AM	5:06 PM	6:07 PM	7:30 PM	6:30 AM	8:45 AM
SAMPLE LOCATION	CV top	CV top	CV top	CV top	CV top	CV top
TEST CONDITIONS						
Mix Components, lb/hr						
SDA (K120 A)	28,000	26,000	26,000	26,000	26,000	25,000
Water	9,750	9,750	9,750	9,750	9,750	10,200
Additive #2	385	475	475	475	475	475
Recycle (K250)	2,000	4,000	4,000	4,000	4,000	6,000
Embedding Material, lb/hr						
SDA (K120B)	7,691	7,382	7,382	7,382	7,382	8,004
Additive #1	2,318	2,497	2,497	2,497	2,497	2,412
CV Top Materials (1)						
Ave. penetrometer reading	3.04	3.14	3.10	2.58	2.76	2.56
Temperature, degree F	165.5	189.2	167.1	167.1	167.1	167.5
Moisture, wt% dry (2)	10.22	10.40	9.72	ND	11.46	5.18

(1) Blend of green extrudates and embedding material
(2) Moisture content of embedding material

TABLE 13 TEST CONDITIONS AND RESULTS OF INTEGRATION RUNS ON 1/20/06 AND 1/20/06

DATE	1/19/06	1/19/06	1/19/06	1/19/06	1/19/06	1/20/06	1/20/06	1/20/06	1/20/06	1/20/06	1/20/06	1/20/06	1/20/06
TIME	9:40AM	10:45 AM	11:10 AM	1:30 PM	2:45 PM	10:40 AM	11:11 AM	11:50 AM	2::50 PM	3:15 PM	3:55 PM	4:20 PM	4:55 PM
SAMPLE LOCATION	Die	CV top	Die	CV top	Die	Die/CV top	Die	CV top	CV top	Die	CV top	Die	CV top
RUN CONDITIONS													
<u>Mix components, lb/hr</u>													
SDA (K120A)	25,000	23,000	21,000	19,000	19,000	29,000	29,000	29,000	29,000	29,000	29,000	29,000	29,000
Water	10,570	10,250	10,200	10,240	10,425	10,590	10,590	10,590	10,590	10,590	10,550	10,590	10,590
Additive #2	220	220	235	220	220	220	220	225	225	215	215	205	205
Recycle (K250)	8,000	10,000	12,000	14,000	14,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
<u>Embedding material, lb/hr</u>													
SDA (K120B)	8,178	8,178	8,178	8,178	8,178	8,178	8,178	8,178	8,178	8,178	8,178	8,178	8,178
Additive #1 (K210)	2,764	2,764	2,764	2,764	2,764	2,764	2,764	2,764	2,764	2,764	2,764	2,764	2,764
TEST RESULTS													
<u>Green Extrudates</u>													
Ave. penetrometer reading	1.45		1.53		1.42	0.97	1.17			0.92		0.91	
Deflection, %	15		15		20	25	20			25		20	
No. of cracks (large)	1		1		3	1	1			1		None	
Moisture, wt% dry	35,84		35.26		36.29	32.69	33.28			33.80		32.34	
<u>CV top materials (1)</u>													
Temperature, deg. F	168.4	164.5		143.0		157.6		151.1	153.5		183.9		164.8
Ave. penetrometer reading	2.62	2.80		3.00		2.71		2.53	2.29		2.45		2.32
Moisture, wt% dry (2)	10.93	11.71		17.46		9.91		6.86	17.27		15.51		11.70

(1) Blend of green extrudates and embedding material
(2) Moisture content of embedding material

TABLE 14 TEST CONDITIONS AND RESULTS OF EXTRUSION RUNS ON 9/3/06

DATE	9/3/06	9/3/06	9/3/06	9/3/06	9/3/06	9/3/06	9/3/06	9/3/06	9/3/06	9/3/06	9/3/06	9/3/06
TIME	1:37 AM	2:15 AM	3:45 AM	4:45 AM	5:45 AM	7:00 AM	8:10 AM	10:36 AM	12:15 PM	5:28 PM	6:23 PM	8:11 PM
SAMPLE LOCATION	Die	Die	Die	Die	Die	Die	Die	Die	Die	Die	Die	Die
TEST CONDITIONS												
Mix Components, lb/hr												
SDA (K120 A)	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	13,000	13,500	13,500
Water	4,325	4,325	4,325	4,325	4,325	4,300	4,300	4,335	4,335	6,000	4,000	4,000
Additive #2	175	175	175	175	185	185	185	185	250	225	200	200
Recycle (K250)	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	6,000	4,000	4,000
Embedding Material, lb/hr												
SDA (K120B)	3,554	3,554	3,554	3,554	3,554	3,554	3,554	3,554	4,489	0	4,438	0
Additive #1 (K210)	1,071	1,071	1,071	1,071	1,071	1,071	1,071	1,071	1,353	0	1,337	0
Pugsealer Vacuum, inch Hg	16	16	15	15	17	17	15	17	17	16	17	13
Extruder Vacuum, inch Hg	20	19	19	20	20	20	20	23	24	22	21	18
Extruder Speed, %	73	75	73	73	73	73	73	66	66	87	92	92
TEST RESULTS												
Green Extrudate												
Moisture, wt% dry	32.85	33.01	33.31	33.00	33.68	32.95	33.03	33.30	ND	35.58	34.47	33.43
Temperature, degree F	121.4	119.9	124.7	118.0	119.8	118.0	117.3	117.9	118.6	128.7	125.7	123.8
Ave. penetrometer reading	1.56	1.81	1.55	1.45	1.48	1.47	1.34	1.73	1.93	1.34	1.77	1.14
Deflection, %	25	20	25	20	25	25	25	25	25	30	25	20
No. cracks	3	2	1	3	1	2	0	1	1	3	3	3

TABLE 15 TEST CONDITIONS AND RESULTS OF INTEGRATION RUNS ON 9/3/06 AND 9/4/06

DATE	9/3/06	9/3/06	9/3/06	9/3/06	9/3/06	9/3/06	9/3/06	9/3/06	9/4/06	9/4/06	9/4/06	9/4/06
TIME	2:27 AM	3:25 AM	4:25 AM	5:25 AM	6:35 AM	7:15 AM	8:21 AM	11:20 AM	2:24 PM	9:50 PM	10:50 PM	11:50 PM
SAMPLE LOCATION	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top	CV top
TEST CONDITIONS												
Mix Components, lb/hr												
SDA (K120 A)	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	14,000	14,000	14,000	14,000
Water	4,325	4,325	4,325	4,325	4,300	4,300	4,300	4,335	5,550	5,550	5,550	5,550
Additive #2	175	175	175	185	185	185	185	185	250	350	350	350
Recycle (K250)	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	4,000	4,000	4,000	4,000
Embedding Material, lb/hr												
SDA (K120B)	3,554	3,554	3,554	3,554	3,554	3,554	3,554	3,554	4,489	4,489	4,489	4,489
Additive #1 (K210)	1,071	1,071	1,071	1,071	1,071	1,071	1,071	1,071	1,353	1,353	1,353	1,353
CV Top Materials (1)												
Ave. penetrometer reading	3.30	3.54	3.45	3.1	3.39	3.24	2.82	2.95	2.89	2.96	2.86	3.04
Temperature, degree F	160.6	151.8	156.8	174.9	155.8	162.0	150.6	149.7	145.6	158.6	157.2	155.4
Moisture, wt% dry (2)	12.87	13.68	9.55	9.06	12.26	10.03	9.02	13.24	9.10	12.97	11.36	9.81

(1) Blend of green extrudates and embedding material
(2) Moisture content of embedding material

TABLE 16 TEST CONDITIONS AND RESULTS OF EXTRUSION RUNS IN DECEMBER

DATE	12/5/06	12/5/06	12/6/06	12/7/06	12/7/06	12/7/06	12/12/06	12/12/06	12/19/06	12/23/06	12/27/06	12/27/06	12/28/07	12/30/06
TIME	9:30 AM	11:25 AM	10:05 AM	7:35 AM	10:45 AM	12:20 PM	4:20 PM	6:46 PM	3:55 PM	5:20 PM	7:45 AM	12:50 PM	7:30 PM	10:00 AM
SAMPLE LOCATION	Die	Die	Die	Die	Die	Die	Die	Die	Die	Die	Die	Die	Die	Die
Mix Components, lb/hr														
SDA (K120 A)	26,000	26,000	26,000	26,000	26,000	26,000	33,000	33,000	26,000	12,000	12,000	12,000	12,000	12,000
Water	8,270	8,270	8,320	8,320	8,320	8,320	10,560	10,560	8,273	3,600	3,600	3,600	3,600	3,700
Additive #2	100	100	0	0	100	0	100	100	100	50	0	0	0	0
Recycle	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pugsealer Vacuum, inch Hg	15	15	16	19	15	16	18.5	21	14	15	17	17	17	20
Extruder Vacuum, inch Hg	19	18	18.5	18	17	18	18.5	20	16	18	19	19	18	19
Extruder Speed, %	100	100	100	100	100	100	100	100	100	100	100	100	100	100
TEST RESULTS														
Green Extrudate														
Moisture, wt% dry	31.42	32.01	30.96	30.55	31.27	31.16	31.14	30.93	31.20	29.65	29.16	28.90	28.97	29.98
Temperature, degree F	ND	ND	111.3	117.9	113.2	111.7	120.5	120.1	114.9	120.4	124.0	131.0	130.8	114.0
Ave. penetrometer reading	1.51	1.55	1.74	1.61	1.55	1.63	1.71	1.75	1.61	1.96	1.91	1.95	2.04	1.71
Deflection, %	30	30	30	25	30	30	30	30	30	27	25	25	20	25
No. cracks	0	0	1	1	0	1	2	1	0	2	0	1	3	0

TABLE 17 TEST CONDITIONS AND RESULTS OF INTEGRATION RUNS ON 12/8/06 AND 12/9/06

DATE	12/8/06	12/8/06	12/8/06	12/8/06	12/8/06	12/9/06	12/9/06	12/9/06	12/9/06	12/9/06	12/9/06	12/9/06	12/9/06	12/9/06	12/9/06	12/9/06
TIME	11:00 AM	12:00 PM	1:30 PM	2:00 PM	3:00 PM	1:00 AM	2:00 AM	3:00 AM	1:00 PM	1:45 PM	2:10 PM	2:45 PM	3:10 PM	3:45 PM	4:45 PM	11:15 PM
SAMPLE LOCATION	Die/CV top	CV top	Die	CV top	CV top	Die	Die/CV top	CV top	Die	CV top	Die	CV top	Die	CV top	CV top	Die/CV top
Mix Components, lb/hr																
SDA (K120 A)	26,000	26,000	26,000	26,000	26,000	28,000	28,000	28,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26000
Water	9,430	9,430	9,430	9,430	9,480	10,000	10,000	9,950	9,580	9,460	9,460	9,460	9,460	9,460	9,460	9460
Additive #2	37	37	75	122	122	0	0	0	45	87	85	87	93	87	87	0
Recycle (K250)	5000	5000	5000	5000	5,000	4,000	4,000	4,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5000
Embedding Material, lb/hr																
SDA (K120B)	7,591	7,591	7,591	7,591	7,591	7,871	7,871	7,871	7,773	7,573	7,573	7,573	7,573	7,573	7,573	7573
Additve #1 (K210)	2,566	2,566	2,566	2,566	2,566	2,661	2,661	2,661	2,560	2,560	2,560	2,560	2,560	2,560	2,560	2560
Pugsealer Vacuum, inch Hg	14	14	15	15	14	15	15	15	15	16	15	14	15	14	15	17
Extruder Vacuum, inch Hg	18	19	18	18	18	19	19	19	18	19	18	18	18	18	19	18
Extruder Speed, %	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
TEST RESULTS																
Green Extrudate																
Moisture, wt% dry	32.47		33.36			33.77	32.87		33.69		33.59		32.54			32.67
Temperature, degree F	107.1		103.0			104.5	102.8		ND		106.6		111.6			105.2

Ave. penetrometer reading	1.56		1.57			1.52	1.44		1.47		1.58		1.50			1.25
Deflection, %	30		30			25	15		30		25		25			30
No. cracks	2		1			0	1		0		1		1			0
CV Top Materials (1)																
Ave. penetrometer reading	3.00	2.95		3.22	2.90		2.96	3.16		2.98		3.00		2.99	3.24	3.18
Temperature, degree F	151.0	165.4		149.4	160.2		149.6	167.5		173.1		163.9		164.6	153.7	173.9
Moisture, wt% dry (2)	7.83	ND		ND	13.09		7.25	10.41		7.25		ND		5.91	6.70	7.67

(1) Blend of green extrudates and embedding material
(2) Moisture content of embedding material

TABLE 18 TEST CONDITIONS AND RESULTS OF INTEGRATION RUNS ON 12/28/06 AND 12/29/06

DATE	12/28/06	12/28/06	12/28/06	12/28/06	12/28/06	12/28/06	12/28/06	12/28/06	12/28/06	12/28/06	12/28/06	12/29/06	12/29/06	12/29/06
TIME	2:20 PM	3:30 PM	4:00 PM	5:00 PM	5:35 PM	6:30 PM	9:00 PM	9:45 PM	10:00 PM	10:45 PM	11:00 PM	5:00 AM	6:00 AM	6:15 AM
SAMPLE LOCATION	Die	CV Top	Die	Die	CV top	Die	Die	CV top	Die	CV top	Die	Die	Die	CV top
TEST CONDITIONS														
Mix Components, lb/hr														
SDA (K120 A)	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Water	5,330	5,330	5,330	5,330	5,330	5,330	5,330	5,330	5,330	5,330	5,330	5,330	5,330	5,330
Additive #2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recycle (K250)	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Embedding Material, lb/hr														
SDA (K120B)	4,166	4,166	4,166	4,166	4,166	4,166	4,166	4,166	4,166	4,166	4,166	4,166	4,166	4,166
Additive #1 (K210)	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408
Pugsealer Vacuum, inch Hg	18	18	18	18	17	17	19	18	19	18	19	19	18	18
Extruder Vacuum, inch Hg	19	19	19	19	19	19	20	19	20	19	20	20	20	19
Extruder Speed, %	100	100	100	100	100	100	100	100	100	100	100	100	100	100
TEST RESULTS														
Green Extrudate														
Moisture, wt% dry	32.19		30.00	32.17		31.27	32.33		33.09		32.91	31.74	32.26	
Temperature, degree F	111.1		119.8	118.9		117.5	128.9		120.5		119.5	118.5	127.9	

Ave. penetrometer reading	1.45		1.58	1.55		1.52	1.64		1.49		1.71	1.63	1.73	
Deflection, %	25		20	25		25	25		20		20	25	25	
No. cracks	2		2	2		1	0		0		1	3	2	
CV Top Materials (1)														
Ave. penetrometer reading		4.13			2.92			4.34		3.36				3.51
Temperature, degree F		153.3			160.2			171.6		175.7				176.0
Moisture, wt% dry (2)		9.05			7.97			6.57		10.42				ND

(1) Blend of green extrudates and embedding material
(2) Moisture content of embedding material

TABLE 19 TEST CONDITIONS AND RESULTS OF INTEGRATION RUNS ON 12/30/06 AND 12/31/06

DATE	12/30/06	12/30/06	12/30/06	12/30/06	12/30/06	12/30/06	12/30/06	12/31/06	12/31/06	12/31/06	12/31/06	12/31/06	12/31/06	12/31/06
TIME	11:30 AM	12:50 PM	1:00 PM	4:00 PM	4:50 PM	7:45 PM	8:45 PM	4:30 AM	5:30 AM	6:30 AM	7:45 AM	4:10 PM	4:35 PM	8:00 PM
SAMPLE LOCATION	Die	Die	CV top	Die	CV top	Die/CV top	Die/CV top	Die/CV top	CV top	Die/CV top	CV top	CV top	Die	Die/CV top
TEST CONDITIONS														
Mix Components, lb/hr														
SDA (K120 A)	12,000	12,000	12,000	12,000	12,000	13,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000
Water	4,830	5,430	5,430	5,430	5,430	5,670	6,700	6,700	6,700	6,750	6,750	6,750	6,750	6,850
Additive #2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recycle (K250)	3,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Embedding Material, lb/hr														
SDA (K120B)	3,645	4,190	4,190	4,190	4,190	4,438	5,174	5,174	5,174	5,174	5,174	5,174	5,174	5,174
Additive #1 (K210)	1,249	1,417	1,417	1,417	1,417	1,501	2,008	2,008	2,008	2,008	2,008	2,008	2,008	2,008
Pugsealer Vacuum, inch Hg	17	19	19	18	18	18	18	17	14	18	18	17	15	15
Extruder Vacuum, inch Hg	19	18	20	18	18	19	17	18	15	18	18	15	17	17
Extruder Speed, %	100	100	100	100	100	100	100	100	100	100	100	100	100	100
TEST RESULTS														
Green Extrudate														
Moisture, wt% dry	30.50	33.04		34.12		32.65	31.25	33.55		32.65			32.96	34.30
Temperature, degree F	ND	ND		ND		112.4	119.4	110.7		112.6			117.3	116.6

Ave. penetrometer reading	1.56	1.63		1.51		1.33	1.43	1.30		1.33			1.36	1.39
Deflection, %	30	28		30		20	30	30		30			30	30
No. cracks	1	1		0		1	1	2		1			1	1
CV Top Materials (1)														
Ave. penetrometer reading			3.54		2.88	3.82	3.50	3.33	3.13	3.28	2.94	3.11		2.77
Temperature, degree F			147.5		169.5	167.2	181.3	181.6	162.5	181.9	170.4	148.2		180.4
Moisture, wt% dry (2)			11.21		ND	9.32	13.06	14.08	12.36	7.52	8.13	9.18		10.57

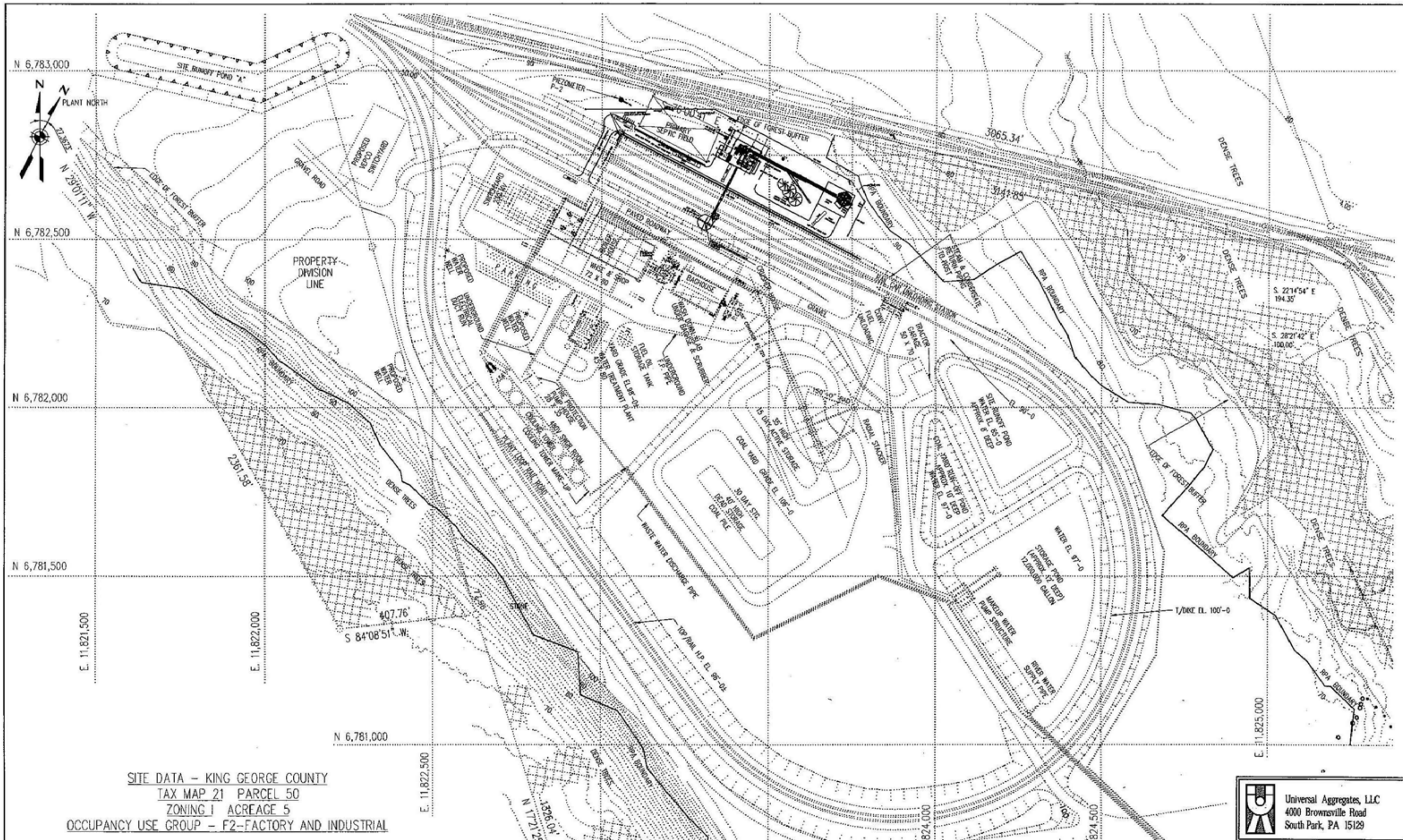
(1) Blend of green extrudates and embedding material
(2) Moisture content of embedding material

TABLE 20 TEST CONDITIONS AND RESULTS OF EXTRUSION RUNS ON 9/2/06 AND 9/5/06

DATE	9/2/06	9/2/06	9/2/06	9/2/06	9/2/06	9/2/06	9/2/06	9/2/06	9/2/06	9/5/06	9/5/06	9/5/06
TIME	1:10 PM	3:00 PM	4:05 PM	5:20 PM	6:20 PM	7:30 PM	8:30 PM	9:30 PM	10:40 PM	7:20 AM	8:09 PM	9:11 PM
SAMPLE LOCATION	Die	Die	Die	Die	Die	Die	Die	Die	Die	Die	Die	Die
TEST CONDITIONS												
Mix Components, lb/hr												
SDA (K120 A)	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	26,000	26,000	26,000
Water	3,600	3,600	3,600	3,600	3,600	3,600	3,600	3,600	3,600	8,350	8,350	8,400
Additive #2	70	70	70	85	85	85	85	85	85	350	350	350
Recycle (K250)	0	0	0	0	0	0	0	0	0	0	0	0
Embedding Material, lb/hr												
SDA (K120B)		3,134	3,134	3,134	3,134	3,134	3,134	3,134	3,134		6,666	6,666
Additive #1 (K210)		944	944	944	944	944	944	944	944		2,009	2,009
Pugsealer Vacuum, inch Hg	11	18	18	18	17	17	17	17	17	13.5	11	11.5
Extruder Vacuum, inch Hg	18	18	19	18	18	17	17	18	18	17.5	15	17.5
Extruder Speed, %	63	63	63	66	74	75	75	74	74	100	100	96
TEST RESULTS												
Green Extrudate												
Moisture, wt% dry	28.83	29.47	30.02	29.45	29.21	29.22	29.75	29.45	29.72	32.29	33.11	33.45
Temperature, degree F	ND	125.6	125.9	126.8	125.9	125.1	126.8	124.7	124.0	115.1	121.4	121.8
Ave. penetrometer reading	1.64	1.90	1.78	1.88	1.91	1.35	1.35	1.55	1.52	1.63	1.52	1.53
Deflection, %	25	25	28	27	28	30	20	23	30	ND	30	30
No. cracks	2	2	1	1	2	2	0	3	1	Nd	3	3

APPENDIX “A”

DRAWINGS



SITE DATA – KING GEORGE COUNTY
TAX MAP 21 PARCEL 50
ZONING I ACREAGE 5
OCCUPANCY USE GROUP – F2–FACTORY AND INDUSTRIAL

OWNER	GENERAL CONTRACTOR	ENGINEER
UNIVERSAL AGGREGATES,LLC	P.J. DICK, INC	R.T. PATTERSON, CO., INC
400 BROWNSVILLE ROAD	P.O. BOX 98100	230 THIRD AVE
SOUTH PARK, PA 15129	PITTSBURGH, PA 15227	PITTSBURGH, PA. 15222
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REV.	DESCRIPTION	DATE			
			DRAWN BY:	STJ	02/01/02
D	ISSUED FOR BUILDING PERMIT	1/17/03	DESIGNED BY:		
C	UPDATED FACILITY LAYOUT	5/14/02	CHECKED BY:		
B	UPDATED FACILITY LAYOUT	4/16/02	APPROVED BY:		
A	FOR REVIEW AND COMMENTS	02/04/02	APPROVED BY:		
			APPROVED BY:		

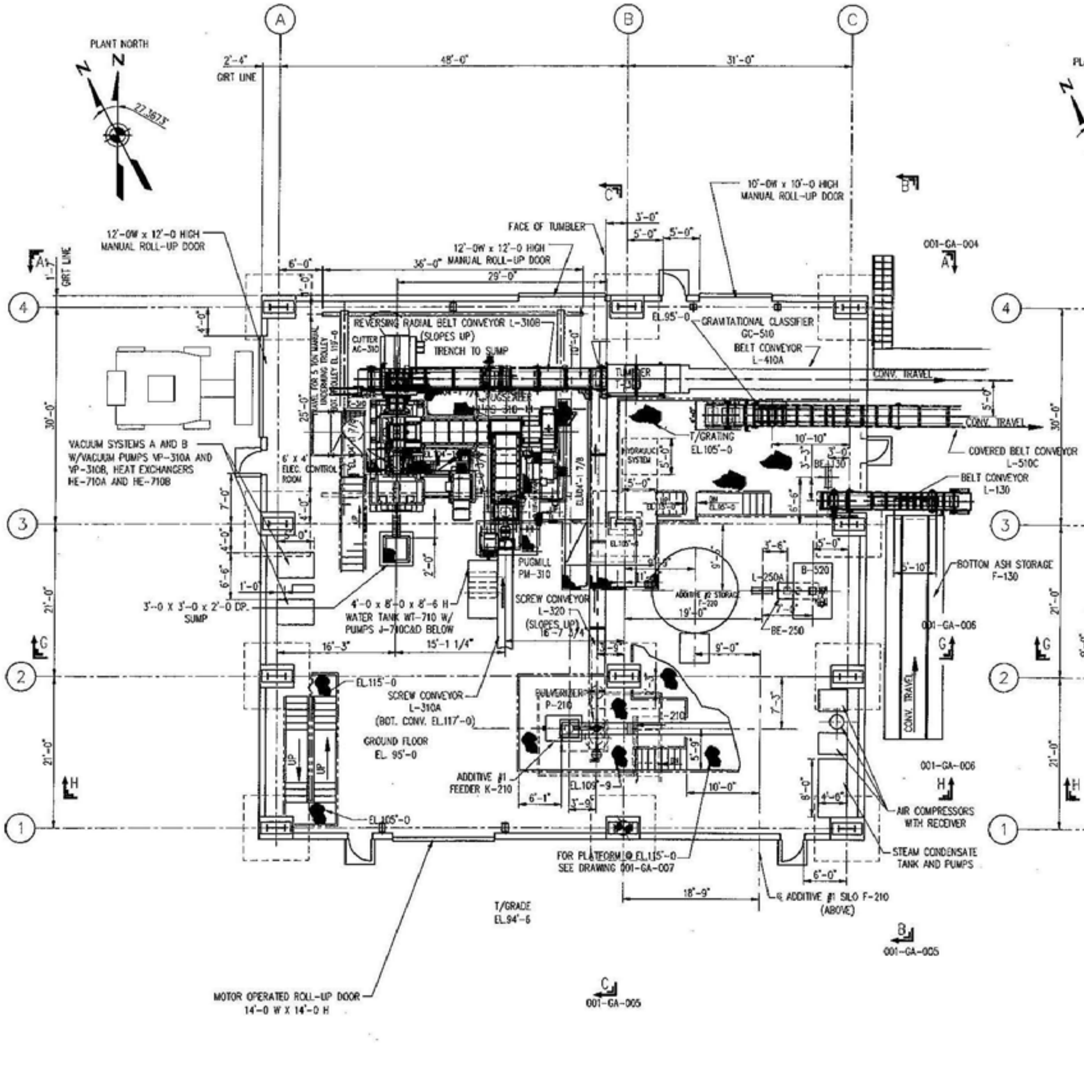
JOB No.AC-7336 PLOTTED:3/27/03 08:01:35
FILE SPEC.: AC-7336\DRAWINGS\001-GA-001.DWG
ENGINEERED BY
R.T. PATTERSON CO., INC.
ENGINEERS & CONSULTANTS
PITTSBURGH PA. ☆ HIGHLAND IN. ☆
EVANSVILLE IN. ☆ CLEVELAND OH. ☆

Universal Aggregates, LLC
4000 Brownsville Road
South Park, PA 15129

BIRCHWOOD POWER FACILITY
MANUFACTURED AGGREGATE PLANT
SITE SURVEY PLAN
NEW FACILITY LOCATION

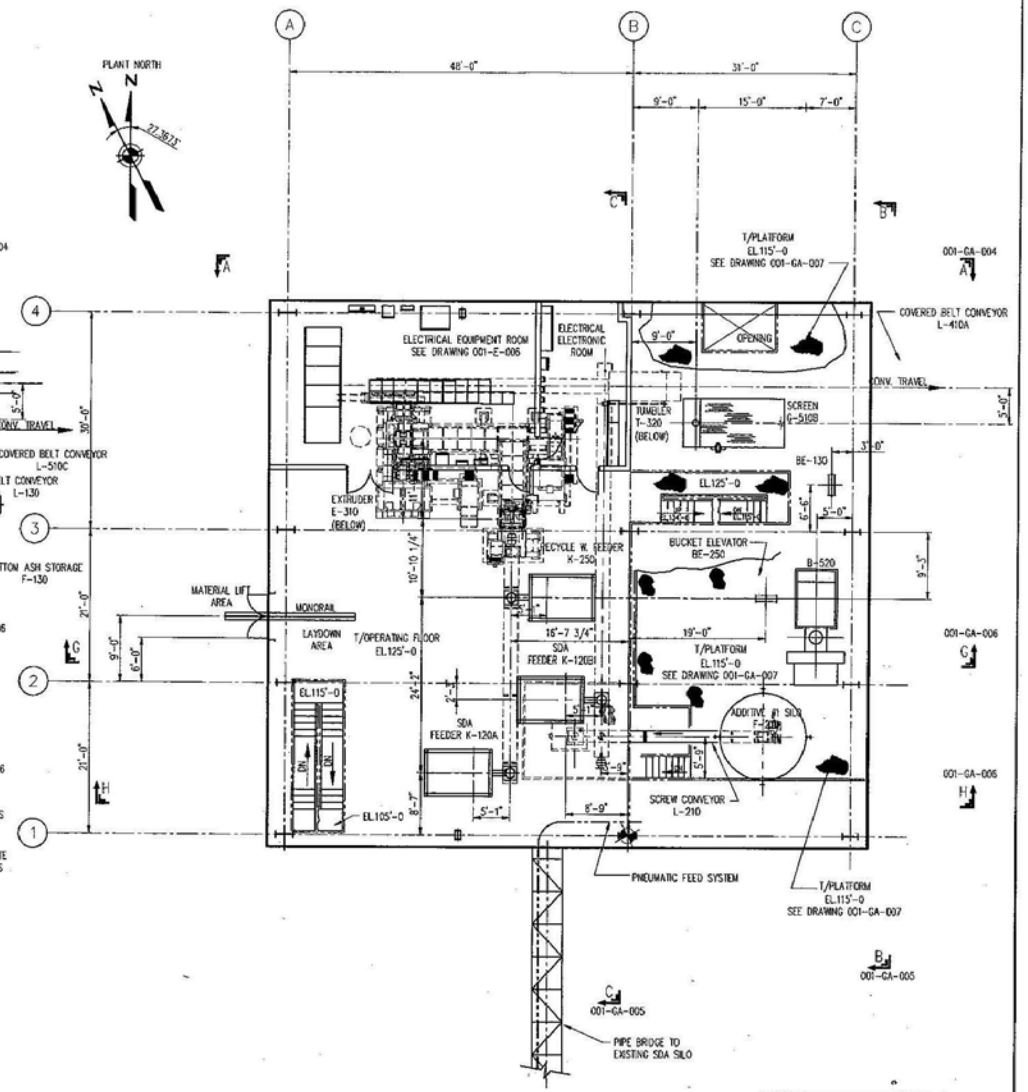
SCALE	JOB NO.	DRAWN	DATE	FILENAME: 001-GA-001.DWG
1"=120'-0"	AC-7336	STU	02/01/02	PLOTTED 3/27/03

001–GA–001 D



GROUND FLOOR PLAN

GROUND FLOOR
EL. 95'-0



OPERATING FLOOR

T/OPERATING FLOOR
EL.125'-0

NOTES:
WORK THIS DRAWING WITH DRAWINGS 001-GA-004, 001-GA-005 AND 001-GA-006

REV.	DESCRIPTION	DATE	REV.	DESCRIPTION	DATE			
			E	GENERAL REVISION	11/20/02	DRAWN BY:	STU	1/15/02
			D	GENERAL REVISION	6/10/02	DESIGNED BY:		
0	FOR CONSTRUCTION		C	GENERAL REVISION	5/14/02	CHECKED BY:		
G	GENERAL REVISION	2/3/03	B	GENERAL REVISION	2/22/02	APPROVED BY:		
F	ISSUED FOR BUILDING PERMIT	1/17/03	A	REV DWG NO AND FOR INFORMATION	02/07/02	APPROVED BY:		
						APPROVED BY:		

JOB No.AC-7336 PLOTTED:4/9/03 13:56:30
ENGINEERED BY
R.T. PATTERSON CO., INC.
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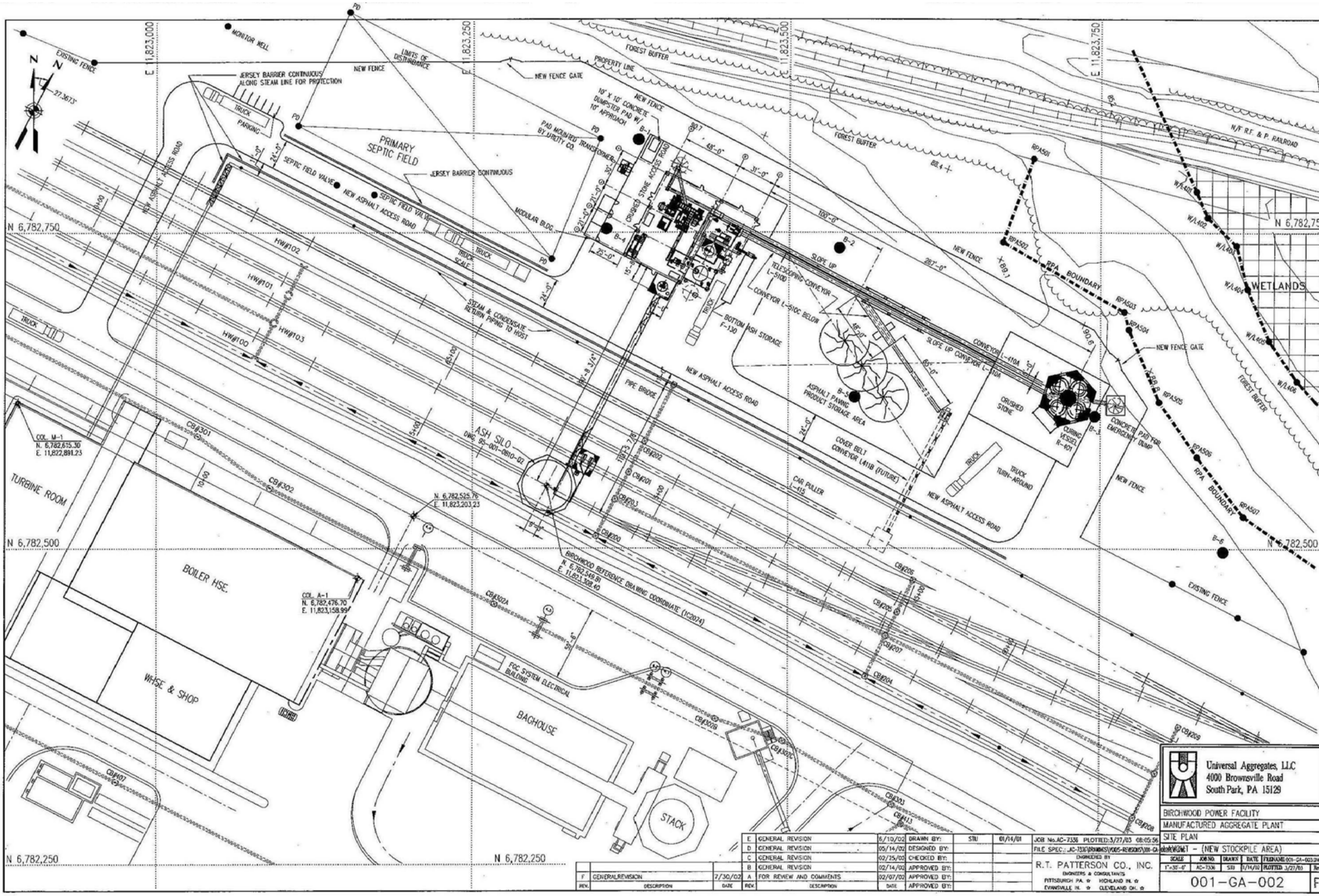
Universal Aggregates, LLC
4000 Brownsville Road
South Park, PA 15129

BIRCHWOOD POWER FACILITY
MANUFACTURED AGGREGATE PLANT
MAIN BLDG. LAYOUT
PLANS & SECTION

SCALE	JOB NO.	DRAWN	DATE	PLOTTED	Rev.
1/8"=1'-0"	AC-7336	STU	1/15/02	4/9/03	

001-GA-003 | 0


Universal Aggregates, LLC
4000 Brownsville Road
South Park, PA 15129
BIRCHWOOD POWER FACILITY
MANUFACTURED AGGREGATE PLANT
SITE PLAN
(NEW STOCKPILE AREA)
R.T. PATTERSON CO., INC.
ENGINEERS & CONSULTANTS
PITTSBURGH PA. HIGHLAND IN.
EVANSVILLE IN. CLEVELAND OH.
JOB No. AC-7336 PLOTTED: 3/27/03 08:05:56
DRAWN BY: STU 01/14/01
DESIGNED BY:
CHECKED BY:
APPROVED BY:
E GENERAL REVISION 6/10/02
D GENERAL REVISION 05/14/02
C GENERAL REVISION 02/25/02
B GENERAL REVISION 02/14/02
A FOR REVIEW AND COMMENTS 02/07/02
F GENERALREVISION 7/30/02
REV. DESCRIPTION DATE
SCALE 1"=30'-0" JOB NO. AC-7336 DRAWN STU DATE 1/14/02 PLOTTED 3/27/03
001-GA-002
F
PRIMARY SEPTIC FIELD
WETLANDS
RPA BOUNDARY
FOREST BUFFER
PROPERTY LINE
NEW FENCE
NEW FENCE GATE
EXISTING FENCE
MONITOR WELL
LIMITS OF DISTURBANCE
JERSEY BARRIER CONTINUOUS ALONG STEAM LINE FOR PROTECTION
JERSEY BARRIER CONTINUOUS
NEW ASPHALT ACCESS ROAD
SEPTIC FIELD VALVE
MODULAR BLDG.
PAD MOUNTED TRANSFORMER BY UTILITY CO.
10' X 10' CONCRETE DUMPSTER PAD W/ 10' APPROACH
CRUSHED STONE ACCESS ROAD
TRUCK PARKING
TRUCK SCALE
STEAM & CONDENSATE RETURN PIPING TO HOST
TELESCOPING CONVEYOR L-510D
CONVEYOR L-510C BELOW
BOTTOM ASH STORAGE F-130
SLOPE UP
SLOPE UP CONVEYOR L-410A
ASPHALT PAVING PRODUCT STORAGE AREA
COVER BELT CONVEYOR L411B (FUTURE)
CAR PULLER L-415
PIPE BRIDGE
ASH SILO DWG. 05-001-0810-02
CRUSHED STONE
CURING VESSEL R-401
CONCRETE PAD FOR EMERGENCY DUMP
TRUCK TURN-AROUND
N/F R.F. & P. RAILROAD
BIRCHWOOD REFERENCE DRAWING COORDINATE (1C2074)
N. 6,782,549.81
E. 11,823,308.40
N. 6,782,525.76
E. 11,823,203.23
COL. M-1
N. 6,782,615.30
E. 11,822,891.23
COL. A-1
N. 6,782,476.70
E. 11,823,158.99
TURBINE ROOM
BOILER HSE.
WHSE & SHOP
BAGHOUSE
FGC SYSTEM ELECTRICAL BUILDING
STACK
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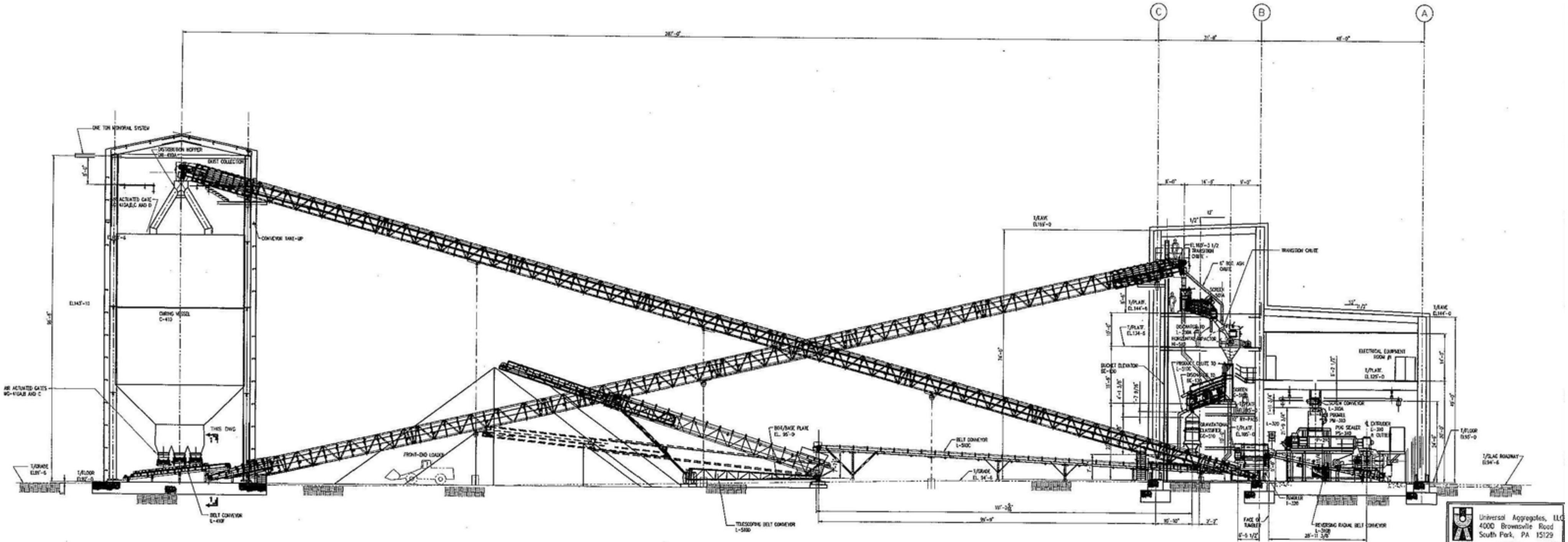


SECTION A–A
BIRCHWOOD POWER FACILITY – "MANUFACTURED AGGREGATE PLANT"
(LOOKING SOUTH)

NOTE:
WORK THIS DRAWING WITH DRAWINGS 001-CA-002, 001-GA-005 AND 001-GA-006

REV.	DESCRIPTION	DATE	REV.	DESCRIPTION	DATE
			E	GENERAL REVISION	10/2/03
			D	GENERAL REVISION	6/10/03
0	FOR CONSTRUCTION	5/19/03	C	GENERAL REVISION	5/14/03
G	ISSUED FOR BUILDING PERMIT	1/17/03	B	GENERAL REVISION	2/22/03
F	GENERAL REVISION	11/20/02	A	REV DWG. NO & FOR INFORMATION	10/01/02

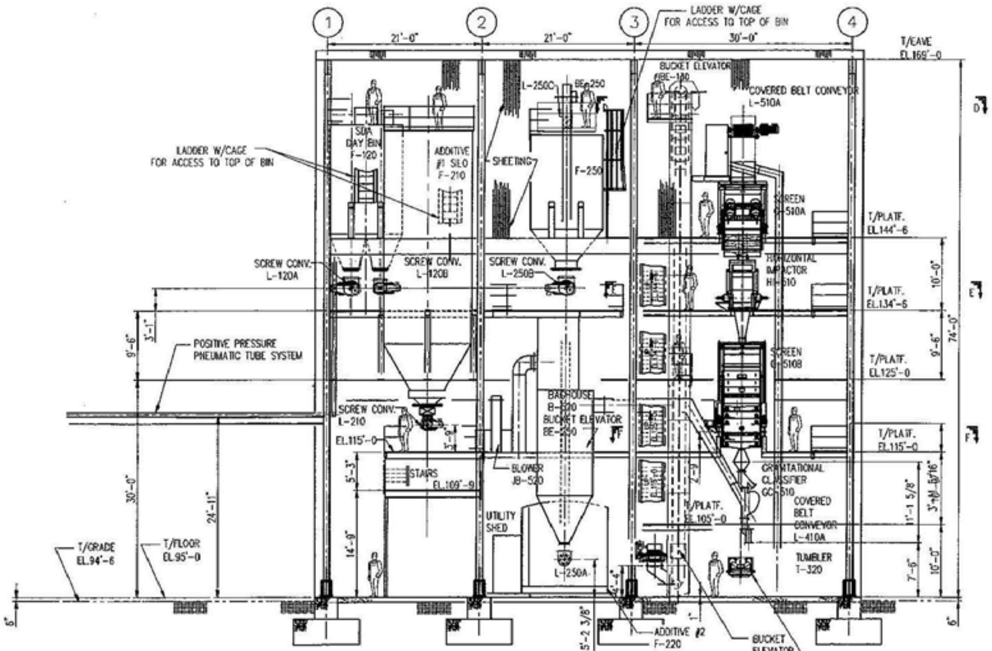
DRAWN BY: STW 1/21/02
DESIGNED BY:
CHECKED BY:
APPROVED BY:

R.T. PATTERSON CO., INC.
ENGINEERS & CONSULTANTS

Universal Aggregates, LLC
4000 Brownsville Road
South Park, PA 15129

BIRCHWOOD POWER FACILITY
MANUFACTURED AGGREGATE PLANT
FACILITY LAYOUT
SECTION

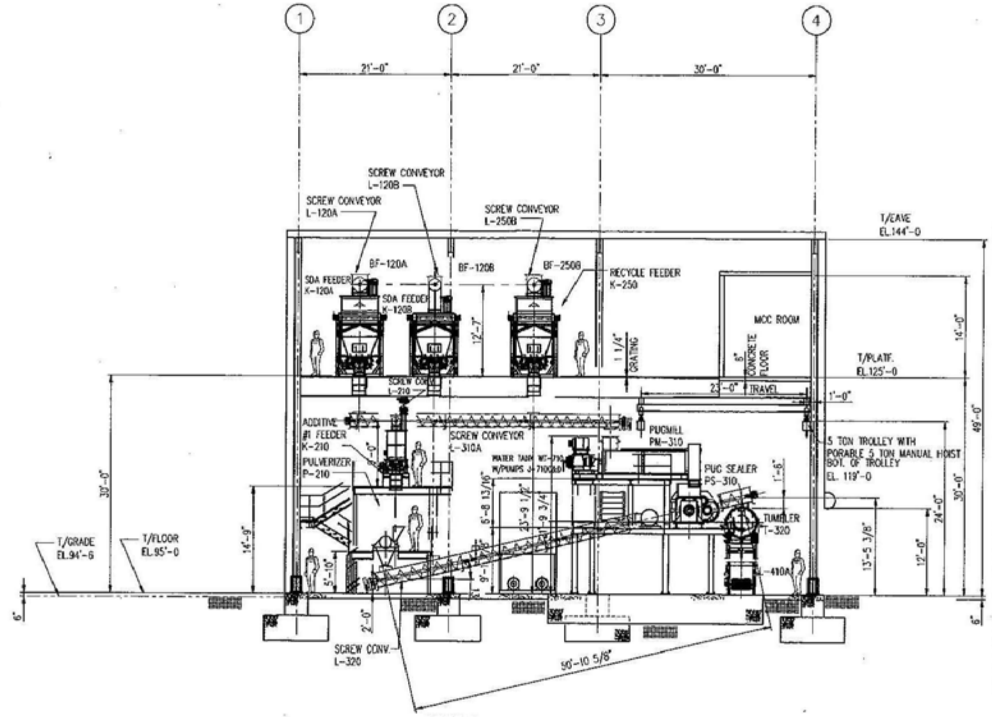
001–GA–004A 0



SECTION B–B

BIRCHWOOD POWER FACILITY – "MANUFACTURED AGGREGATE PLANT"

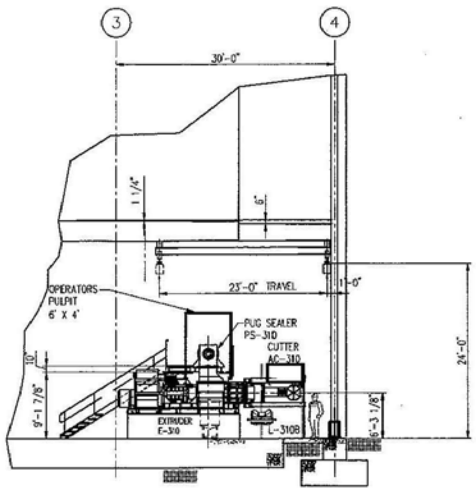
(LOOKING WEST)



SECTION C–C

BIRCHWOOD POWER FACILITY – "MANUFACTURED AGGREGATE PLANT"

(LOOKING WEST)



SECTION J–J

NOTE:
WORK THIS DRAWING WITH DRAWINGS 001-GA-003, 001-GA-004, AND 001-GA-006

REV	DESCRIPTION	DATE
D	FOR CONSTRUCTION	
G	GENERAL REVISION	2/3/2003
F	ISSUED FOR BUILDING PERMIT	1/17/03

REV	DESCRIPTION	DATE			
E	GENERAL REVISION	11/20/02	DRAWN BY:	KRF	02/06/02
D	GENERAL REVISION	6/10/02	DESIGNED BY:		
C	GENERAL REVISION	5/14/02	CHECKED BY:		
B	GENERAL REVISION	2/22/02	APPROVED BY:		
A	FOR INFORMATION	02/07/02	APPROVED BY:		
			APPROVED BY:		

JOB No. AC-7336 PLOTTED: 4/9/03 13:49:09
FILE SPEC.: AC-7336\DRAWINGS\001-GA-005.DWG
ENGINEERED BY
R.T. PATTERSON CO., INC.
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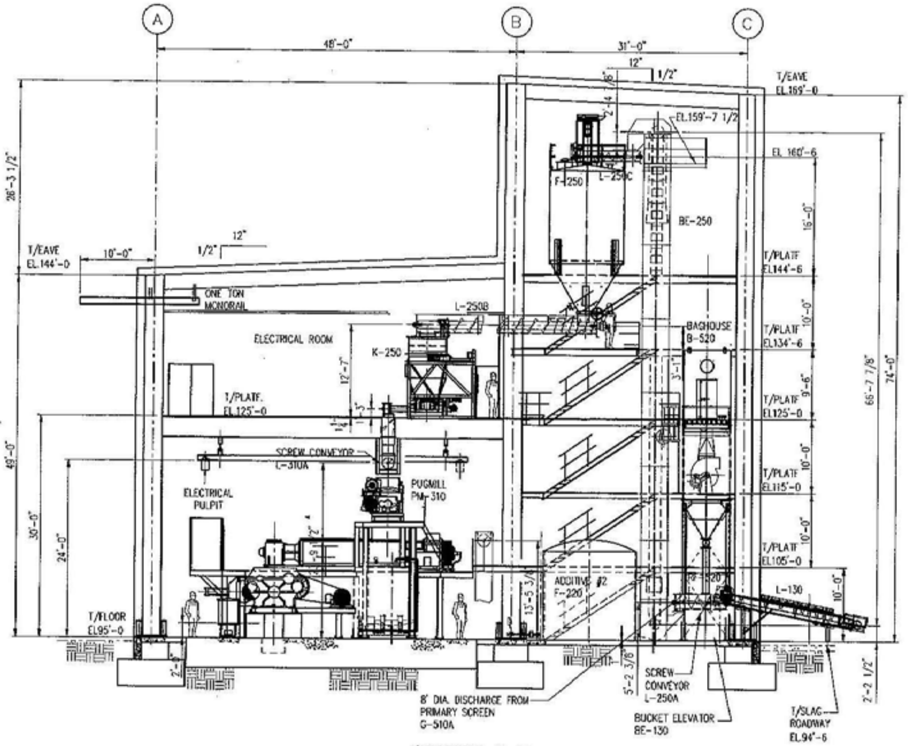
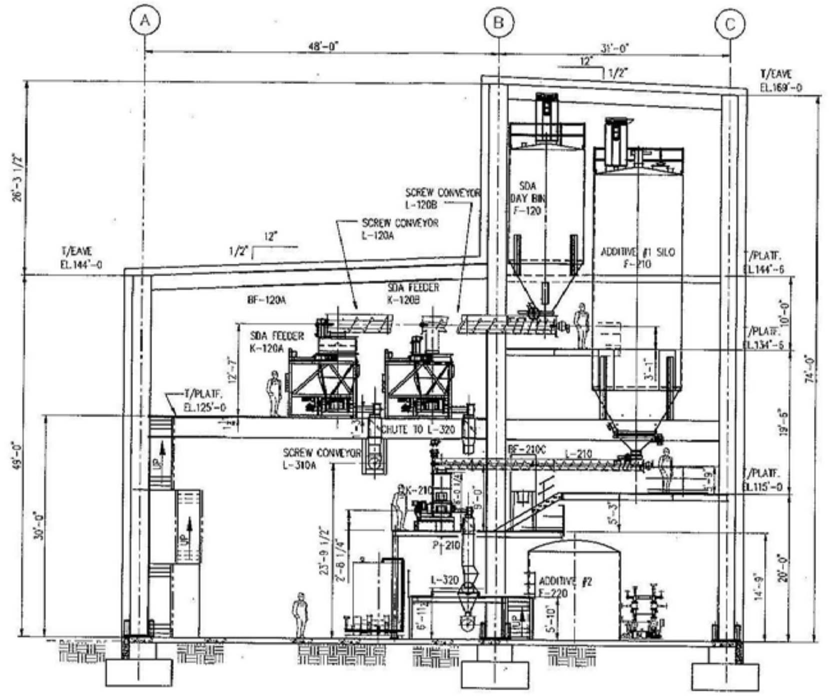
BIRCHWOOD POWER FACILITY
MANUFACTURED AGGREGATE PLANT
MAIN BLDG. LAYOUT
PLANS & SECTION

SCALE	JOB NO.	DRAWN	DATE	FILENAME
1/8"=1'-0"	AC-7336	STU	1/15/02	001-GA-005.DWG PLOTTED 4/9/03

001-GA-005 Rev. 0



SECTION G-G
DWG. 001-GA-003



SECTION H-H
DWG. 001-GA-003

NOTES:
WORKK THIS DRAWING WITH DRAWINGS 001-GA-003, 001-GA-004, 001-GA-005, AND 001-GA-007

REV.	DESCRIPTION	DATE	REV.	DESCRIPTION	DATE			
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			C	GENERAL REVISION	11/20/02	CHECKED BY:		
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0	FOR CONSTRUCTION	5/19/03	A	REVIEW AND COMMENTS	5/14/02	APPROVED BY:		
						APPROVED BY:		

JOB No.AC-7336 PLOTTED:7/9/03 07:38:37
FILE SPEC.: AC-7336\DRAWINGS\001-GA-006A.DWG
ENGINEERED BY
R.T. PATTERSON CO., INC.
ENGINEERS & CONSULTANTS
PITTSBURGH PA. ☆ HIGHLAND IN. ☆
EVANSVILLE IN. ☆ CLEVELAND OH. ☆

Universal Aggregates, LLC
4000 Brownsville Road
South Park, PA 15129

BIRCHWOOD POWER FACILITY
MANUFACTURED AGGREGATE PLANT
MAIN BLDG. LAYOUT
SECTION

SCALE	JOB NO.	DRAWN	DATE	FILENAME: 001-GA-006.DWG	
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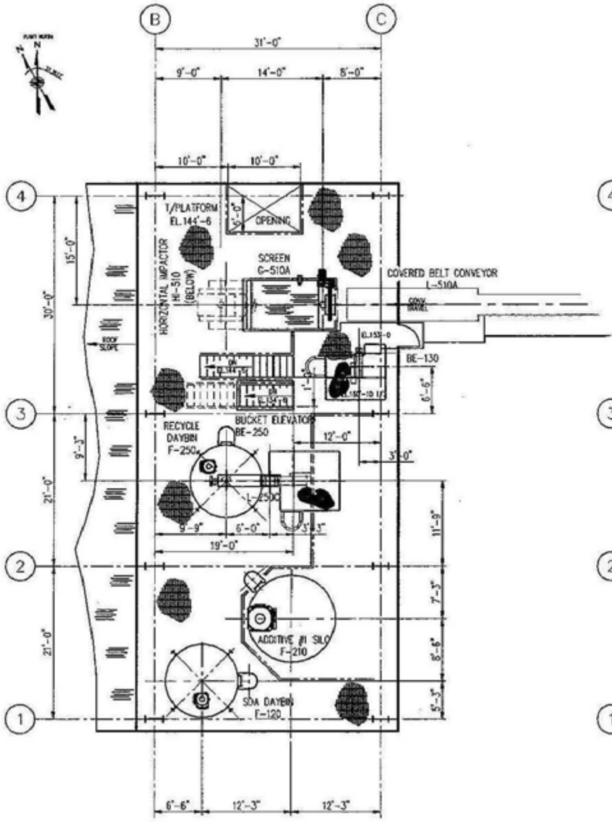
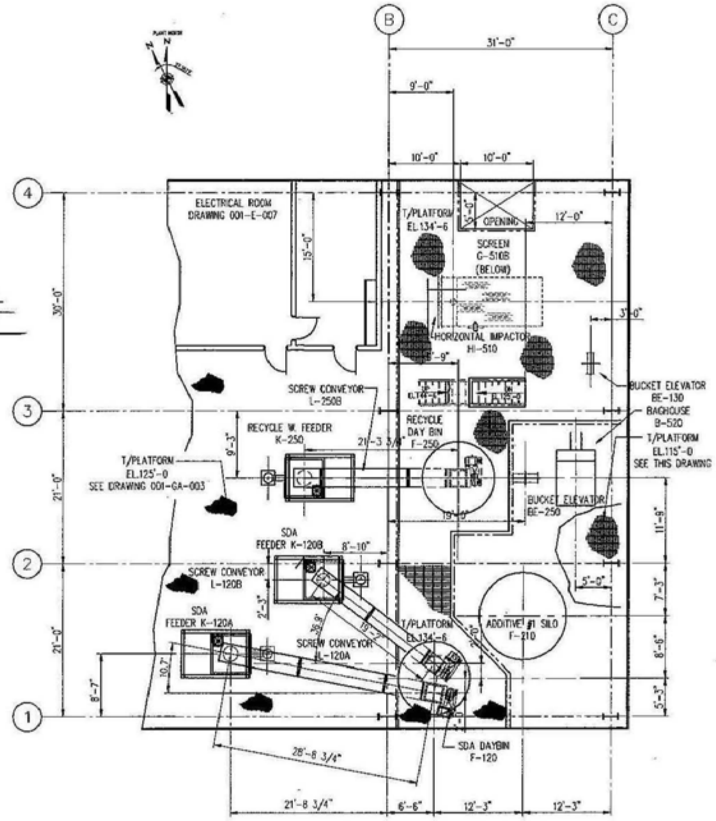
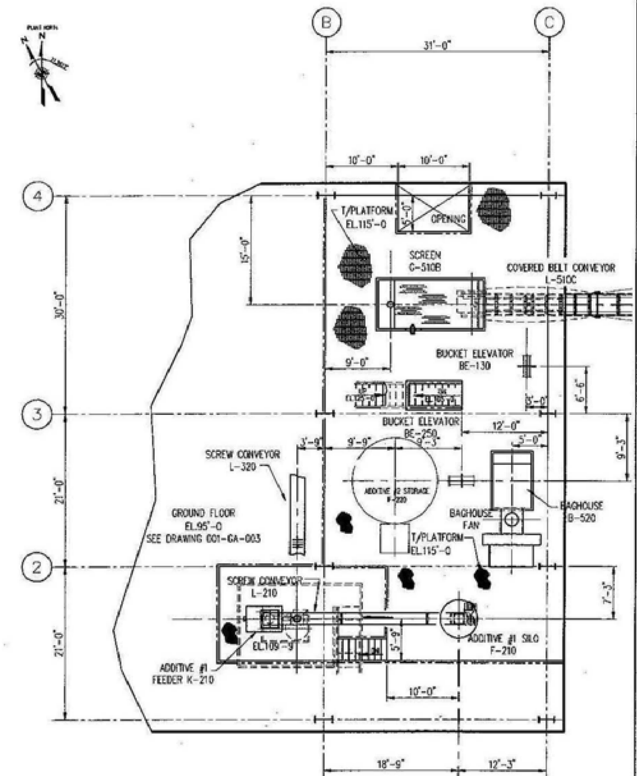
001-GA-006A					0



SECTION D-D
T/PLATFORM
EL.144'-6



SECTION E-E
T/PLATFORM
EL.134'-6



SECTION F-F
T/PLATFORM
EL.115'-0"

NOTE:
WORK THIS DRAWING WITH DRAWINGS 001-GA-003, 001-GA-004, AND 001-GA-006

REV.	DESCRIPTION	DATE	REV.	DESCRIPTION	DATE			
						DRAWN BY:	KRF	02/06/02
						DESIGNED BY:		
						CHECKED BY:		
						APPROVED BY:		
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						APPROVED BY:		

JOB No.AC-7336 PLOTTED:4/9/03 14:11:07
FILE SPEC.: AC-7336\DRAWINGS\001-GA-007.DWG
ENGINEERED BY
R.T. PATTERSON CO., INC.
ENGINEERS & CONSULTANTS
PITTSBURGH PA. ☆ HIGHLAND IN. ☆
EVANSVILLE IN. ☆ CLEVELAND OH. ☆

Universal Aggregates, LLC
4000 Brownsville Road
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BIRCHWOOD POWER FACILITY
MANUFACTURED AGGREGATE PLANT
MAIN BLDG. LAYOUT
PLANS & SECTION

SCALE	JOB NO.	DRAWN	DATE	FILENAME 001-GA-004.DWG
1/8"=1'-0"	AC-7336	STU	1/15/02	PLOTTED 4/9/03

001-GA-007 REV. 0

APPENDIX “B”

PLANT OPERATION HISTORY

Plant Operations History

Universal Aggregates began startup operation efforts in April 2004. That process was continued until December 2006. A summary of those efforts follows.

<u>2nd Quarter 2004</u>

With the improvements in the ash handling system at the end of April, we were able to operate at 10,000 pounds an hour of ash; roughly 13% of our capacity into the pug mill, pug sealers, and finally an attempt into the extruder. Five attempts were made at passing material through the extruder die. Unfortunately each time we were unsuccessful in completely getting material through the die. The die as assembled, is a composite of about five pieces approximately 7-8 inches thick. We would run all the way up to about an inch and a half short of the end of being able to push something out of the die. We were now staffing and operating 24 hours a day. We were working through revision (3) to the extruder die and made reparations to integrate the plant with green extrudates into the curing vessel. Installation of a pin-type mixer for producing alternate daily cover and road base material for landfill applications was started and completed. Universal Aggregates took over complete ash processing and disposal responsibilities effective June 20$^{th.}$ Site visits were conducted by the equipment manufacturer in support of optimizing the pugmill, the pugsealer and the extruder in combination. A new 2-inch diameter opening 27-hole die was installed.

We continued to have problems with the physical properties of the ash. With the help of our mixing consultant we went back to fine spray atomization nozzles for the water and we also tested a wetting agent for the process water to help with mixing in the pugmill. We installed a dam in the pugmill to increase retention time. With the help of the equipment manufacturer we ran some tests on the pugsealer to try and determine its optimum performance. We continued to have the same problem with the extruder that we had in the past. The material would pack and bridge over the flights within the extruder auger barrel-limiting throughput. When the extruder was fresh and clean, we were able to produce a mix that was extrudable for a short period of time using the 2-inch diameter die, however the extrudate was still quite soft.

A program was initiated to monitor qualities of spray dryer ash from the Birchwood Power Plant and wetted ash collected at the pugmill, pugsealer and extruder outlets. Monitored results were being correlated with process operating conditions. Qualities of spray dryer ash monitored include moisture content, hydrated lime content and bulk density. Qualities of wetted ash monitored include: moisture content, bulk density and temperature. Process operating conditions include ash and water feed rates, equipment power consumption and others.

A parametric test was conducted to evaluate the effects of the pugmill dam installation, water injection nozzle configuration, and overall water addition on pugmill performance. Test results indicate that better water and ash contact can increase densification of wetted ash in the pugmill. Better water and ash contact at a constant water addition could be achieved by installing a high dam near the pugmill outlet to increase retention time and installing fine spray nozzles to reduce water droplet size. Increased water addition can also increase the densification of wetted ash in the pugmill.

3rd Quarter 2004

Hydrated lime content in the SDA was identified as an important factor that influences extrusion performance. SDA with hydrated lime content above 24% was difficult to extrude, due to increased stickiness of the wetted ash. Several continuous extrusion runs with a 2" straight die were conducted successfully using SDA with hydrated lime content below 24% between July 7, and July 9. However, extruded products were crumbly with fractured pieces comprising over 50% of the material. Addition of silica sand and gypsum in the mix feed and reduction of mix feed temperature did not improve the extrusion performance. Hydrated lime content in the SDA increased above 24% after July 13, due to a switch to low sulfur and low ash coals at the Birchwood Power Plant (BPP). In early September, BPP implemented a spray dryer modification program for lime optimization, which reduced hydrated lime content in the SDA. Reduction in hydrated lime content in the SDA to 24% and below was observed in late September. Hydrated lime content in the SDA was monitored twice a day for quality and process control.

Properties of wetted ash, collected at the pugmill outlet, were monitored after pugmill modifications. Better ash densification with reduced moisture content was achieved by increasing pugmill speed and dam outlet height, installing higher pressure water pumps, changing blade position, and adding a bridge in the center of pugmill. Several admixtures were evaluated as an extrusion aid to improve extrusion performance.

Three admixtures were identified, which can produce extruded products with improved plasticity and reduced moisture content. The extruder was modified by installing porcelain -enameled auger and reversed liners for extrusion. Several continuous extrusion runs with a 2" straight die installation were conducted successfully at Birchwood in late September. Extruded products with structural integrity were produced with few fractured pieces.

4th Quarter 2004

Extrusion runs were conducted continuously with adequate water and admixture addition in the pugmill. Extruded products with good structural integrity and few fractured pieces were produced with the 1.25" and 2" diameter die installation. Moisture content and temperature of extruded products were monitored to correlate with operation conditions for quality and process control. Extruded products made from both dye installation were collected and charged separately to a heated 55-gallon drum for curing. Curing conditions were simulated to those in curing vessel for aggregate production. Both extruded products developed high crush strength after curing. The cured products were crushed and screened to proper size gradation for use in production of concrete masonry units (CMU) at the National Concrete Masonry Association (NCMA) for evaluation.

Hydrated lime content in spray dryer ash (SDA) and calcium utilization in spray dryer for sulfur removal were determined to monitor the progress of the spray dryer modification program for lime optimization at the Birchwood Power Plant (BPP). Hydrated lime content in SDA decreased from high 20% in July to September to low 20% and below in October to December. Calcium utilization increased from high 10% to low 20% in the same period. Both indicated the success in implementation of the program at BPP. Decrease in hydrated lime content in SDA can reduce the stickiness of wetted ash and improve extrusion operation.

Mix designs were recommended for curing vessel feed and the integration runs with recycle fines from the curing vessel. A program was implemented to monitor the quality of the recycle fines and the aggregate products. Quality evaluation of the recycle fines included moisture content, hydrated lime content and size gradation, which are all related to the curing operation. The quality of aggregate products includes bulk density, size gradation and fineness modulus. Changes in quality of recycle material and aggregate products were monitored during the integration runs in December. Test results will be used as a reference to monitor performance of future integration runs.

Lightweight aggregates produced through the “commercial” extrusion process were cured in bench–scale, curing vessels to examine strength development and compliance for “specification” quality. The cured extrudates were crushed and screened to meet the applicable gradation requirements for use in concrete masonry. Using the mix design of a local masonry producer (future buyer), this lightweight aggregate product was then utilized to produce concrete masonry units at the National Concrete Masonry Association (NCMA) in Herndon, Virginia, meeting and exceeding the applicable ASTM quality requirements for compressive strength, absorption, unit weight, and density.

The Birchwood station underwent their fall outage lasting approximately seven (7) days. During that period UA performed maintenance on F-120 relief valve, dust collectors, ash transport system, the pin mixer, extruder, pugsealer and pugmill. We switched to a 1.25” diameter extrusion dye. We were able to successfully send material to the tumbler and up into the curing vessel on Oct 14th. This lasted for approximately seven (7) hours, before we plugged the inlet to the vessel. We modified the inlet cone and cleaned up the spillage. We were able to try the modified inlet one more time for approximately three (3) hours, before plugging the plant dust collector and forcing the unit off line. The power station continued to work on reducing their lime consumption and producing a lower lime content ash. Recent values were in the low to mid 20s. We are still testing various admixtures as extrusion aids. Both of these items have allowed the plant to start and produce extrudates on demand.

During the month of November we conducted tests on a 1” dye as well as a single wing point auger. We were unable to run the 1” dye with any degree of success with its current configuration, nor were we able to run the single wing point auger as received. The single wing point auger that we tried has no gap for pins and it appears, based on our evaluation of that auger, that we do need to have pins to prevent barrel rolling. The double wing point auger was reinstalled with the gap for the pins. During the month of November we did see a higher carbon level in the ash because of classifier tuning and mill maintenance on the Birchwood Power Plant Facility. During the week of November 15th we did perform an extended extrusion run. We were at 40% capacity and overall for the four (4) days we were approximately 70% available. On the 17th , we were approximately 90% available. We attempted to go to the curing vessel all four days but because of nuisance problems we were unable to do so. We had a meeting with the equipment manufacturer at the Birchwood Plant, looking at modifications and improvements to the pugmill, pugsealer, and extruder.

During the month of December we continued to work towards integration of the plant finally achieving integration on December 16. Integration was achieved at approximately 30% capacity. We also began shipping crushed aggregate around the middle of the month. This crushed aggregate is a mixture of manufactured lightweight aggregate as well as the Solite startup aggregate that was initially loaded into the curing vessel. We were able to extrude up until we reached a high carbon ash near the end of the month. By testing different ad mixtures, we were able to find one that allowed us to extrude reliably. We were also working to resolve an issue with the ash transport system that we experienced during the severe cold spell. We were limited in ash transport to about 12,000 pounds an hour, which is about 25% capacity. The steam system was energized to preheat process water on December 28th.

In December, Universal Aggregates plant processed 1592 tons of SDA for aggregate production and alternate daily cover to the landfill. There was approximately 150 tons of lightweight aggregate in inventory on the ground at the end of the month, and the sales broker shipped about 431 tons of crushed aggregates to a concrete masonry producer. The consumer/user (a Maryland masonry producer) successfully manufactured concrete masonry using Universal Aggregates' commercially produced, lightweight aggregate product.

1st Quarter 2005

The first week in January, the plant was down for scheduled repairs and modifications to the curing vessel, recycle line, and SDA transport line. The plant resumed operation January 10th. On January 17th , we went to 7/24 operation. The plant was down on the 25th of January to disassemble and clean out the extruder. Work continued on improving operability of the production facility. We continued with refinements to the mix design and admixture addition rate. We had production problems with the tumbler because of a build up in the lining and with high moisture recycle material plugging the recycle feeder.

Universal Aggregates' production from January thru March 2005 allowed the distribution of approximately 700 tons of lightweight aggregate to a product consumer.

At the beginning of March, we were successful with continued integration of the Birchwood facility. We were producing aggregate, loading and selling aggregate from the stockpile. We developed an issue with the curing vessel inlet and curing vessel balance between the four individual sections of the vessel. An investigation was conducted in support of our operating problems, and it was determined that we were short cycling C can. We were only operating on C can. B – 5

We need to operate with all 4 cans and 3 feeders in service for uniform flow through the CV.

Hydrated lime and carbon contents in spray dryer ash (SDA) were characterized to monitor ash quality in this quarter. The average of hydrated lime contents was 21.2% with standard deviation of 1.3%, which was similar to those in previous quarter. The carbon contents in SDA were mostly in the range of 3.9 to 4.5%, except that SDA had higher carbon contents (4.5 to 6.1%) from February 8 to February 22. The increase in carbon content was caused by a coal pulverization malfunction at Birchwood Power Station. One coal mill (out of four) for coal pulverization was taken out of service for repair. Increase in water addition was needed to make mixed ash plastic enough for extrusion. The average moisture content of extruded products taken from February 8 to February 22 was about one percent higher than those made from SDA with carbon contents of 3.9% to 4.5%.

Mix designs with reduced fines were recommended for curing vessel feeds. A new test procedure for QA/QC was implemented to monitor qualities of reacted embedding material and recycle. Qualities monitored include moisture content and hydrated lime content, which are related to curing and crushing operation.

Lightweight aggregates produced through the "commercial" extrusion process were cured in bench-scale curing vessels to examine strength development and compliance for "specification" quality. The cured extrudates were crushed and screened to meet the applicable gradation requirements for use in concrete masonry. Using the mix design of a local masonry producer (future buyer), this lightweight aggregate product was again utilized to produce concrete masonry units at the National Concrete Masonry Association (NCMA) in Herndon, Virginia. The concrete masonry units produced in this demonstration also meet and exceed the applicable ASTM quality requirements for compressive strength, absorption, unit weight, and density.

<u>2nd Quarter 2005</u>

Early in April we attempted to send extrudates back into the curing vessel, operating only on the east side of the vessel, the B & D cans. We tried that unsuccessfully for two days. The levels in B & D were fluctuating radically. Visual inspection showed we were developing a rat hole through both cans down to the feeders at the bottom. We operated like this in March with poor results, so we terminated the activity. The decision was made to go ahead and completely drain the vessel.

During that activity, for about a week, the level in C can did not change at all. A blasting contractor was brought in to inspect the situation and subsequently contracted to set off charges inside the curing vessel to drop the level in C can. This activity took about a day and a half at the end of the month, followed by clean up of the remaining aggregate in the curing vessel. The curing vessel design engineer inspected the empty curing vessel on April 26th. Work for the outage, including contractor meetings and procurement of necessary items, continued for the month. Engineering drawings were prepared and the contractors were mobilized at the end of April**.**

Birchwood completed their outage work and re-started on May 13th. It wasn't until Tuesday the 17th that the UA plant had SDA to process. The UA plant did a cold start and equipment check on Tuesday the 17th. We started processing ash on the 18th.

Modifications completed during the outage:

(1) Sealer dam + 2 new knives.

(2) Extruder liner, single wing gap point auger.

(3) Pugmill, 4 new knives + water injection system

(4) Curing Vessel rotary chute installed (electric, controls, heat trace & insulation to be completed).

(5) Replaced product oversize chute.

(6) Replaced recycle chute.

(7) Water filtration.

(8) SDA silo valves & vent line tune-up.

(9) Instrument replacement & upgrade in several locations + PLC program mod's.

(10) Acrison SDA feeder VFD on intromitter drive + re-direct. Only achieved a slight speed reduction.

(11) Complete list of maintenance items.

The modifications worked very well. The only thing that was not a major improvement was the two (2) new knives downstream of the pugsealer dam. They bent over and one eventually broke off. They were replaced. The four (4) in the pugmill are not turned and appear to be OK.

The plant started in under an hour extruding at 12,000 lb/hr SDA and ramped up to 18,000 lb/hr SDA. On May 19th, the plant went to 20,000 & 24,000 lb./hr SDA. The SDA feeder became unstable at 24,000 lb/hr (66% cap) otherwise we continued to extrude that whole time. The bump in feed rate that occurs after a refill is not a result of flushing, but the way the feeder restarted out of volumetric mode. The manufacturer's engineer made a site visit on May 25th and corrected this. The unit continued extruding until the 28th. The extrudates are soft and crumbly, but the moisture has been down as low as 27.5%. The modifications appear to allow us to operate in a wider extrudable band.

On the 28th, the plant changed liners out; the one-piece S/S liner was polished to a mirror finish & lost its grip for forward push. The replacement parts went in without the pins and the use of a continuous wing point auger.

3rd Quarter 2005

The parametric tests to increase stiffness of "green" extrudates were completed in early July. It was identified that relatively strong extrudants can be produced at high SDA throughput and high extruder vacuum with the addition of recycle material. We completed refill of the curing vessel with the blend of expanded shale and limestone (50/50), and confirmed operation of the curing vessel new rotary distribution chute. The UA plant was operated steadily at 18,800-20,000 lb./hr. extrusion for most of the time in July. The steady operation demonstrated that recent modifications in the pugmill, pug sealer and extruder were successful to improve extrusion operation.

A test program was conducted to examine curing vessel velocity profiles at different outlet belt feeder speeds. The objective was to adjust the speeds of the three discharge belt feeders (410B, 410C and 410D) to achieve uniform or near uniform flow with circulation of the expanded shale and limestone blend in the curing vessel. The aggregate blend was distributed automatically via the rotary chute to the four cans (A, B, C and D). Radar probes were used to monitor can levels. Dowel probes were inserted in the four main vessel mainways (AB, BC, AC and BD) to determine velocity profiles from August 2 to August 18. Dowel and radar readings were used at two different locations to determine velocity profiles and gradients in the four cans for comparison.

Test results indicated that there were no significant velocity gradients across any of the curing vessel cans and movement of the refill aggregate blend was slightly higher in C and D cans (south) than those in A and B cans (north). Material in the main vessel manways was mostly in the dead zone with relatively slow movement. Coarse aggregate was segregated onto L- 410 C belt feeder (center).

The curing vessel design engineer visited Birchwood to participate in the testing and to evaluate test results and curing vessel performance on August 23 and 24. The design engineer confirmed the higher material movement in C and D cans, and estimated the dead zone in the main vessel at about 7%. The differential velocity may be corrected by inserting a wedge plate in the feeder outlet. In essence, he concluded that there were no problems in charging the curing vessel with extrudates and embedding material. He recommended operating the L-410 B feeder (west) and L-410 D feeder (east) at an equal discharge rate with L-410 C pulsing for material movement in the center. Charge of the curing vessel with extrudant and embedding material was initiated on August 26. The UA plant was operated at 14 ton/hr SDA feed rate including SDA in the embedding material.

During the month of September, we continued to work towards integration of the plant, including continuous operation of mixing, extruding, curing, screening and crushing for aggregate production. The plant was operated with a dry SDA feedrate of 14 to 15 tons/hr., including SDA in the embedding material with a 64.8% availability. The plant produced about 1,500 tons of extruded products through the curing vessel for aggregate production up to September 24. The rest was sent to landfill for use as alternative daily cover. About 1,000 tons of crushed aggregate products were shipped to concrete masonry producers. Problems in the tumbler, recycle feeder, pugsealer and screen operation and recycle quality inhibited continuous aggregate production. The Birchwood Station underwent their Fall outage from September 24 to 28. Work conducted at the plant during the outage included modifications of the tumbler, recycle feeder, screen, pugsealer, ash and water injection system, and cleaning of pugmill and pugsealer. The objective of these modifications is to improve plant availability for aggregate production.

Quality of extrudates at the exit of the die plate and at the entrance of the curing vessel was monitored to insure sufficient stiffness for a curing vessel charge. Properties of curing vessel materials (in and out), and recycle were characterized for process monitoring and quality control. Samples collected had consistent unit weight and size gradation, indicating adequate performance of the curing vessel operation.

It is estimated that the recycle still contained 20% to 25% of the refill blend containing expanded shale and limestone aggregates. This material can decrease stiffness of extrudates at high feedrates as a mix component in pugmill. Crushed aggregates collected from the stockpile met lightweight specifications in unit weight and size gradation. Hydrated lime and carbon contents in the SDA were characterized to monitor ash quality. The average of hydrated lime contents were 11.3 ± 2.4 in August, 13.0 ±1.8 in September, and 16.5 ± 2.4 in October. The carbon contents in the SDA were in the range of 3.9% to 4.5%. Both were suitable for extrusion.

4th Quarter 2005

During the month of October, the front end of the plant (pugmill/extruder) had been performing well. SDA had been processed through the plant at throughputs between 24,000 and 29,000 lb per hour (pph). Some downtime was required to implement some modifications, e.g. adjusted pitch on pugmill knives in effort to improve retention, installed new water spray nozzles. In addition, part of a shift was lost resolving lubrication issues with the pugsealer bearing. The new nozzles improved the wetting of the material, but additional refinement was required. Several items prevented sending material to the CV, including servicing seized rotary valves, clearing sludge from scrubber tank, cleaning scrubber blower, and failed circuit boards on the variable frequency drive (VFD) for the crusher. When all of the above were completed, a ten-hour continuous run to the CV was completed on October 15.

Later in October, the plant was down on numerous occasions due to necessary repairs/maintenance, including a failed extruder blower motor, a broken control wire on the stacker conveyor, replacing a damaged belt on the stacker conveyor, a thorough cleaning of the pug mill/sealer/extruder, and a broken shear pin on the extruder feed auger. Modifications (by outside contractors) to the CV pant legs and the rotary chute prevented sending material to the CV for three days. Subsequent adjustments to the rotary chute were required to prevent mechanical binding/failures. Intermittent runs to the CV were executed initially at 29,000 pph SDA with 4,000 to 6,000 pph recycle added to the mix (rather than exchanged). Some runs were completed (2 to 6 hour duration) at 25,000 pph SDA plus 8,000 pph recycle. At these higher throughputs, the quality of the extrudates deteriorated somewhat, but the penetrometer readings sustained acceptable levels.

These results tend to validate our discussions with the equipment manufacturer to slow down the speed of the pugsealer. Operations to the CV were halted by other items including: replacing a broken belt on the 410D conveyor (bottom of CV), replacing drive belts on the lime pulverizer motor (which occurred shortly after replacing the screen in the pulverizer), and intermittent mechanical failures of the rotary chute. Large chunks at the discharge of the CV (cause of 410D belt failure) have occurred more frequently and must be addressed.

In November, the front end of the plant (pugmill/extruder) continued to operate at an improved level of reliability. SDA was processed through the plant consistently at 29,000 pph and recycle material had been introduced at feed rates as high as 12,000 pph. At these higher throughputs, the quality of the extrudates again deteriorated, but the penetrometer readings consistently sustained at acceptable levels. Over Thanksgiving weekend, the plant was in operation with product being sent to the curing vessel about 12 to 14 hours in total. Problems that halted operations to the CV included a weather-related power outage, an apparent error in the PLC logic that controls the rotary chute, and a loss in ash feed from Birchwood's ash silo.

During the month of December, about 4,260 tons of dry SDA were processed through the plant and approximately 800 tons of cured aggregate were produced. Operations to the curing vessel continued on intermittent intervals lasting between 4 and 12 hours. On one occasion, operations to the CV extended for about 34 hours within a 36 hour period. Temporary electrical modifications were implemented so that the pugsealer could be operated and evaluated at reduced speeds on a trial basis. This evaluation was cut short as the sealing core auger of the pugsealer failed during the trial period. The sealing core auger was replaced with a prototype auger that was designed by the equipment manufacturer for UA testing, and fabricated many months ago. The prototype design incorporates a 1.3:1 compression ratio versus a 2.5:1 compression ratio of the original auger. Evaluation of the prototype auger continued into January. At months end, an oversight in the control logic caused a large overrun/spillage at the top of the CV. This overrun in turn forced the main conveyor belt off track, which prevented any further runs to the CV.

The management team, reorganized in October, continued its effort to identify and evaluate problem areas throughout the plant, including the ash transfer system beneath the Birchwood ash silo, control of ash level and excess air in the SDA day bin, dust control at the bottom of the CV and throughout the main plant, the wet scrubber and dust control at the top of the CV, and refinements to the PLC control logic.

Discussions with relevant vendors and engineering firms regarding these problem areas are ongoing. A conference call was held with the extrusion engineer on October 16. The call included a discussion about increasing vacuum at the pugsealer. The manufacturer's engineer emphasized that the sealer must not be starved for material and suggested we consider slowing down the pugsealer shaft by means of a jackshaft. A dust collection consultant from was contracted, and on site to tour the plant and offer his recommendations. Dialogue was initiated in October and continues with conveyor design engineers regarding options/modifications to the CV discharge and recycle loop of the CV. These engineers are responsible for original design/engineering of the CV discharge and the supplier of the two multifold conveyor belts. Some follow-up discussions have taken place with all of the manufacturers engineering representatives. Alternative means to slow the speed of the pugsealer are under evaluation. The design engineer for the screw conveyors was onsite to offer recommendations on possible modifications. Conveyor belt maintenance engineers were onsite (Oct. 31) to make recommendations on various items including belt tensioning hardware, polymer slide bars in place of pulleys (L-410F belt, base of CV), and rubber for skirting. In late December, design for the CV recirculation feed system onto L-410A conveyor belt was finalized. An order was placed for a 6,000 ACFM dust collector to address the dust emissions at the bottom of the CV. A circulation pump and necessary plumbing were specified and installed so that a water reducing admixture can be purchased and stored in the existing bulk additive tank, rather than in totes.

Tests were conducted to evaluate the effect of pugsealer speed on pugsealer and extruder operations and on properties of green extrudates. Test results showed that the extruder vacuum could be increased with reduction of pugsealer speed to improve structural integrity of green extrudates for aggregate production. It is advantageous to have a drive to control speed for pugsealer operation. Lump materials collected from bottom of curing vessel had high moisture contents. The high moisture content indicated that lump formation in curing vessel was caused by steam condensation in curing vessel. Ventilation ductwork of curing vessel was modified to reduce or eliminate steam condensation for lump formation.

Hydrated lime and carbon contents in spray dryer ash (SDA) were monitored for ash quality in this quarter. The average of hydrated lime contents increased from October ($11.5 \pm 2.4\%$), to November ($13.9 \pm 2.4\%$) and to December ($18.6 \pm 1.1\%$).

The increase in hydrated lime content is related to the change in spray dryer operation at BPP. The carbon contents in SDA were mostly in the range of 3.9 to 5.0%. Both are adequate for aggregate production.

A waste oil-fired unit for space heating the high bay area of the plant was installed. A large gear reducer was installed to directly drive the rotary chute at the top of the CV in an effort to overcome any mechanical binding. Additional flighting for the L-310 screw conveyor was installed so that SDA is delivered to the pugmill in a more uniform fashion. Replacement electronics were installed on the radar level instrument for the SDA day bin. A belt scale was installed on the stacker belt to meter tonnage of produced aggregate product. An elbow on the SDA transport piping was removed, inspected (~50% blockage), and replaced.

1st Quarter 2006

During the month of January, more than 6,000 tons of dry SDA were processed through the plant and approximately 700 tons of cured aggregate were produced. On January 1, a Roots air blower used to transport SDA from Birchwood's ash silo failed. A replacement blower was expedited and installed. Considerable manpower was devoted to cleaning spillage and re-tracking the L410A conveyor belt at the top of the CV. Upon inspection, it was determined that the ventilation ductwork connecting the four cans of the CV to the wet scrubber/blower were nearly plugged and in need of immediate attention. All ductwork was removed, cleaned, and re-installed as necessary. After further evaluation, the ductwork was re-configured to reduce the flow of air/dust from the cans and eliminate plugging in the future. Following the above work, operations to the curing vessel were able to resume on intermittent intervals lasting between two (2) and eight (8) hours. At mid-month, a failed bearing on the lime pulverizer was replaced. Additional downtime was required to service/replace belts on two of the three conveyor belts beneath the CV (L-410B and L410D). At month's end, a 3-day outage was scheduled for major maintenance to the pug mill, pug sealer and extruder. Service technicians from the equipment manufacturer were on-site to assist with this work.

In February, 5,732 tons of dry SDA were processed through the plant and 965 tons of aggregate were produced. Operations to the curing vessel were completed on intermittent intervals lasting between two (2) and eight (8) hours. With assistance from the equipment manufacturers technicians, the extruder liners and augers were removed, thoroughly cleaned and re-installed. In addition, the pugmill and pugsealer were cleaned and both sealing core augers were replaced.

Plant operations were halted when SDA feed was lost due to a failed bearing on the rotary valve beneath Birchwood's silo. Following a heavy snowstorm, the plant endured an extended power outage (~32 hours). Heavy chunks at the base of the CV impeded operations and led to a belt failure (L410D). At month's end, SDA feed was halted due to a broken gearbox that drives the rotary valve beneath Birchwood's silo.

In March, more than 6,000 tons of dry SDA were processed through the plant and 627 tons of aggregate were produced. One forced outage was scheduled by UA to complete installation of the new dust collector on top of the SDA day bin. At the base of the CV, contractors installed a 6,000 CFM dust collector, ductwork, and applied sheet metal skirting around the inclined conveyor belt (L410F). UA personnel completed the necessary electrical and plumbing work on the two new dust collectors and both are performing well. Significant time and effort was spent clearing conglomerations in the CV cans and pantlegs. In addition, the CV was recirculated extensively to aid in clearing any build-up and to balance the cans. Water spray nozzles at the pugmill were cleaned and replaced as necessary to improve water distribution. At month's end, the main SDA feeder (K120A) began performing erratically, which limited plant operations. Consequently, the manufacturer's field technician was scheduled for a service visit.

Engineering continued its efforts on the following problem areas of the plant: ash transfer system beneath the Birchwood ash silo, improve operability of the lime pulverizer, the wet scrubber and dust control at the top of the CV, repeated mechanical failures of rotary valves, transfer of pulverized lime to the tumbler, performance of recycle feeder (K250) and refinements to the PLC control logic. Discussions with all relevant vendors and engineering firms regarding these problem areas were ongoing. A guided radar level transmitter was specified, installed, and performing well on the SDA day bin. A 1,800 CFM bin vent dust collector was received and installed to address the excess air problem in the SDA day bin. Installation details and equipment specifications for the CV recirculation feed system were finalized with the designer. A vibratory feeder and a bin vent were ordered in accordance with the engineer's design. A 7,000 CFM dust collector was ordered to address dust control areas throughout the main plant. Bids were received and evaluated for a tank mixer to agitate diluted admixtures once it was purchased and stored in the existing bulk additive tank. All drawings were approved and fabrication was begun for the CV recirculation feed system. An eductor/blower system was ordered to convey discharging solids from the new 7,000 CFM dust collector (top floor of main plant).

Conveyor design engineers were on-site to discuss equipment and design options for improvements to the distribution of product at the top of the CV (replace rotary chute). Discussions with other engineering firms on this subject are ongoing. The plant control and logic program engineer was on-site to review all proposed PLC modifications. Performance issues with recycle feeder were observed and corrective actions discussed with manufacturer. Engineers supervised installation and start-up of two new dust collectors. Delivery and installation of all equipment associated with the new CV recirculation system was scheduled for April.

The effects of ambient temperature and embedding material quality on curing vessel operation were evaluated during integration runs. Procedures to improve curing vessel operation were recommended. Hydrated lime and carbon contents in spray dryer ash (SDA) were monitored for ash quality in this quarter. The averages of hydrated lime contents were 16.8±2.4% in January, 16.5±2.3% in February and 12.8±2.9 in March. The decrease in hydrated lime content in March was related to improvement in spray dryer operation at BPP. The carbon contents in SDA were mostly in the range of 3.9 to 5%. Both are adequate for aggregate production.

Two elbows on the SDA transport piping were removed, inspected, and replaced. A belt scale was installed at the top of L510A conveyor belt to meter tonnage of incoming product from the CV. Temporary ductwork was installed to relieve excess air in the SDA day bin by interventing to the Recycle day bin. A broken shear pin was replaced on the extruder feed auger. A leaky knife gate valve and a failed rotary valve were replaced beneath Birchwood's SDA silo. The belt scraper on conveyor L310B was relocated and serviced. A failed motor (25 HP) for the wet scrubber blower was replaced. Maintenance was necessary to service the rotary chute and clean the pantlegs at the top of the CV. Time was devoted to troubleshooting malfunctioning radar level instrumentation in the top of the CV cans. The drive belts on the lime pulverizer were serviced and re-tensioned to improve operability. A belt scale was installed on conveyor L310B (extruder discharge). A belt (L510D belt conveyor) and two belt scrapers were replaced. Three additional access ports were added to the top of CV can '"C".

<u>2nd Quarter 2006</u>

In April, approximately 3,700 tons of dry SDA were processed through the plant. Extensive maintenance, repairs and installation of new equipment were completed throughout the plant this month.

Consequently, there was no aggregate production. In early April, BPP was down for more than five days due to a fire in the boiler and other operational problems. Weight feeder service technician was on-site for two days addressing erratic performance of SDA feeder K120A. Numerous discussions were held with BPP personnel concerning the source and corrective actions for incoming tramp metal and SDA lumps. The CV was manually cleared and recirculated extensively, while the temperature and moisture of the material were monitored.

In May, approximately 6,700 tons of dry SDA were processed through the plant. Maintenance and installation of new equipment continued this month. PLC control logic for the new equipment and motor sequences was loaded and tested (RTP). Start-up of the new CV recirculation system was completed and the system was operated extensively. In total, more than 4,000 tons were re-circulated through the CV. In conjunction with the recirculation, efforts to clear deposits in the CV cans were accomplished by manually air lancing and pneumatic moling. UA contacted the CV design engineer to schedule a site visit to further evaluate the current condition of the CV. An existing slide gate at the base of the SDA daybin was configured to operate automatically with feeder refills. This action eliminated intermittent flushing, which greatly improved control of SDA feed to the pugmill. On May 27, a record single-day total SDA throughput for the plant was achieved (414 tons).

In June, approximately 6,850 tons of dry SDA were processed through the plant. On several occasions in June, mild evening weather prompted BPP to cycle the power plant off (typically midnight to 6 am). All SDA generated at BPP were transported for use in landfill daily cover, none for landfill disposal. Recirculation and evaluation of the CV continued. The CV design engineer was on-site to observe and advise on the condition of the CV. Subsequently, the UA team decided to empty the CV prior to charging with green extrudates. The secondary screen and horizontal impactor were adjusted so that all coarse material could be scalped/preserved and used to recharge the CV. Extensive prep work and safety training were completed in advance of evacuating the CV. At month's end, the CV was approx. 90% empty and more than 560 tons of cured material were stockpiled and covered.

Engineering continued its efforts on the following problem areas of the plant: repeated mechanical failures of rotary valves, transfer of pulverized lime to the tumbler, performance of recycle feeder (K250), flushing of screw conveyor L120A, performance of scrubber at top of CV, alternative level instruments for CV cans, and current status of CV.

Upon identifying tramp metal and other debris as the cause of rotary valve failures, a custom sieve was designed and fabricated for the inlet to the SDA bin. Screw conveyor engineer was on-site to review and analyze performance issues with two existing screws (L120A and L320) and letdown screw options at the top of the CV.

UA engineers consulted with the equipment manufacturer for the design and fabrication of a larger discharge chute for the lime pulverizer. Consultation was also made with the slide gate manufacturer regarding the duty cycle of existing valve on SDA daybin. Consequently, engineering directed to automate the operation of the slide gate valve with feeder K120A refills. Following recommendations from the weigh feeder engineer a smaller auger and cylinder were ordered for the K250 recycle feeder. Pinch valve parts were specified to improve control and simplify adjustment of water discharging from the scrubber. UA consulted with the controls and instrumentation design engineer and instrument vendors regarding instrument options for top of CV. Engineers supervised contractors for the installation of the new CV recirculation system, dust collector at elevation 144', all new ductwork, and catwalks around feeders K120A and K120B. Material handling engineers were on-site to discuss material handling options at the top of the CV and other topics.
While on-site in June, the CV design engineer recommended installation of flow dampers mounted to the base of the internal pintle of the CV. Such dampers would be externally adjustable and enable biasing of material flow through the CV, if necessary. Subsequently, a conceptual design sketch of the dampers was prepared and forwarded to the fabricator. A detailed design was finalized and fabrication is still underway. During the design of the dampers, the fabricator compiled the design drawings of the CV into a user-friendly three dimensional software package. The result was a 3D model of the CV that offered an excellent visual of the entire vessel, which aided in the evacuation effort. All engineering was completed for the new water spray box at the inlet to the pugmill.

Lump (or chunk) samples collected from bottom of curing vessel were characterized during curing vessel cleanup and discharge. The causes of most lump formation were identified. The recent equipment and control modifications should reduce or eliminate lump formation in future curing vessel operation. It is also important to implement the QA/QC program to insure proper operation during curing vessel charge. Hydrated lime and carbon contents in spray dryer ash (SDA) were monitored for ash quality in this quarter. The averages of hydrated lime contents were 11.7±3.2% in April, 9.0±2.7% in May and 9.8±1.5 in June.

The decrease in hydrated lime content from the last quarter is related to improvement in spray dryer operation at BPP. The carbon contents in SDA were mostly in the range of 3.9 to 6.2 %. Both are adequate for aggregate production.

New conduit and wiring was routed throughout the plant to accommodate all new equipment. All new wiring changes were documented through drafting and design. Rod magnets and access doors were installed beneath BPP's ash silo to address incoming metallic debris. The L120A screw conveyor was disassembled to inspect existing flighting and shrouding. Subsequently, two sections of shrouding (10' in total) were reinstalled at a lower position to reduce clearances and increase mechanical resistance. A conveyor maintenance contractor was contracted to replace two belts (L510C and L310E). The sheaves on screw conveyor L320 were changed to double the speed of rotation. Additional access ports were added to the top of all CV cans. The customized chute for the rotary distributor was installed at the top of the CV. Installation of conduit and wiring for all new equipment was completed. The new discharge chute for the lime pulverizer was received and installed. The wet scrubber tank and blower was cleaned/serviced. Replacement instruments were specified for failed pressure transmitters at pump discharge lines at the scrubber and the process water tank. In order to process SDA and discharge the CV simultaneously, an auxiliary conveyor belt was installed on the ground floor. Corporate safety department procured hardware and conducted necessary training to allow UA personnel to safely enter and work inside the CV (e.g., confined space, supplied air, rigging). An existing unused belt conveyor in the plant was relocated to the base of the CV to facilitate recharging the CV. Contractors installed a pantleg discharge box on the top of the 'D' can. A new auger and cylinder were installed on the recycle weigh feeder (K250). Contract electricians have begun conduit work for the installation of the new motor (400 HP) and variable speed drive for the pugsealer.

3rd Quarter 2006

In July, approximately 7,348 tons of dry SDA were processed through the plant. Efforts to evacuate the curing vessel (CV) continued. Upon completion, internal measurements of the CV were obtained and discussed with the design engineer. Preparations to recharge the CV were completed and recharging commenced the week of July 10. Limestone and expanded shale were again procured as necessary to complete the recharge of the CV.

In mid July, a three-day plant outage was scheduled to 1) complete installation of 400 HP motor and variable speed drive for the pugsealer, 2) install rakes in the pug mill, 3) install new water spray box and auxiliary spray nozzles, and 4) complete modifications to the PLC control logic. The installation of the rakes was abandoned due to insufficient clearances. Upon completion of recharging the CV, recirculation, velocity profiling, and preparations to charge the CV were completed. On July 25, UA resumed full production of the plant including operations to the CV. All recent modification appeared to be performing well. Extruded product passed established QA/QC checks both at the extruder discharge and at the inlet to the CV. At months end, approximately 900 tons of aggregate were produced.

In August, approximately 7,970 tons of dry SDA were processed through the plant. Full production of the plant including operations to the CV continued. Aggregate production for the month totaled 3,036 tons. Recycle material was integrated into the pug mill on a continuous basis at 2,000, 4,000, and 6,000 PPH. Efforts to integrate 8,000 PPH of recycle into the mix resulted in a flushing condition through the K250 recycle feeder. Established QA/QC limits for extruded product were maintained and documented both at the extruder discharge and at the inlet to the CV. A plant outage was scheduled on August 16 to replace worn/broken knives (5) in the pug mill. This action resulted in improved mixing in the pug mill. At month's end, BPP initiated an outage that lasted approximately 48 hours due to an underground water line break. During this month, additional plant downtime was necessary for the following reasons: service/repair rotary chute at inlet to CV (two occurrences), thorough cleaning of the pug mill and pug sealer (two occasions), and a power outage prompted by heavy rains (tropical storm Ernesto).

In September, approximately 5,400 tons of dry SDA were processed through the plant. Milder weather caused BPP to operate at reduced loads this month (i.e. dispatched off-line in the evenings). Consequently, UA operated at lower throughputs to match BPP with intermittent operations to the CV. Typical feedrates to the pug mill were 17,000 SDA with 5,000 PPH of recycle material. Aggregate production for the month totaled 1,732 tons. The air classifier, which had been bypassed for more than a year, was brought on-line this month and performed well. Further evaluation and tuning to the classifier are required to establish the desired gradation of fines in our product. BPP went off-line on September 23, which began an extended outage that lasted for more than 30 days. UA processed SDA until BPP's silo was nearly empty and then began emptying the CV.

During the evacuation of the CV, approximately 900 tons of aggregate were scalped, stockpiled, and covered so that it could be used to re-charge the CV. At month's end, UA personnel entered the CV for final cleaning and inspection.

Engineering was on site to support plant operations including recharge and evaluation of the CV, assembly and installation of new water spray box, preparations prior to the re-starting the plant, troubleshoot eductor problems, evaluate performance of wet scrubber, air classifier and water spray box, coordinate and supervise contract workers, miscellaneous support of daily plant operations, assess options for the weigh feeders, and make preparations for the October outage.

The CV flow dampers were fabricated and delivered in July, however, installation was not completed as efforts to recharge the CV were underway. A replacement eductor for the discharge of the plant baghouse (BF550) was installed and evaluated. Performance problems continued with the new eductor. In September, the eductor was returned to the manufacturer to be fitted with air lances. Engineers continued to adjust and evaluate both airflows and water drain lines of the wet scrubber (top of CV). UA. consulted with the weigh feeder engineer regarding the flushing of the K250 recycle feeder. All recommendations offered by the weigh feeder manufacturer were implemented. A new pneumatically operated slide gate was ordered to replace the manually operated valve on the discharge of the recycle bin (F250).

A site visit was scheduled with the manufacturer of the wet scrubber to analyze our application at the top of the CV. The UA team met with engineers from the fabricator to discuss a twin shaft pug mill to replace the existing single shaft pug mill. An order was placed with the weigh feeder manufacturer for two replacement feed mechanisms for the discharge of feeders K120B and K250. The new feeder discharges would be equipped with rotary valves to eliminate any flushing of material through those feeders.

The QA/QC program was implemented in each shift during an integrated run for aggregate production. Throughout production, the quality of green extrudates produced was monitored at three separate locations (extruder, CV charge, and CV discharge) to insure that established quality specifications for these locations were maintained. The objective was to improve operation in aggregate production. Technical support was provided for mix and curing vessel charge formulation, aggregate product evaluation, recirculation operation and monitoring.

A modified shear plate was installed and tested in the pug sealer. The small-hole design improved quality of extruded product, however, the plate was removed due to the inability to sustain continuous operations. A meeting was held with personnel from a bottom ash distributor/broker to discuss possible future business opportunities. Contract electricians completed the installation of the new motor (400 HP) and variable speed drive for the pug sealer.

Mechanical contractors were employed to service the screw conveyor and slide gate valve at the discharge of recycle bin (F250), modify the chute work at the inlet to the air classifier, and install new ventilation ductwork at the top of the CV cans. The new ductwork, which connects the CV cans to the scrubber, was also heat traced and insulated. A small spout was installed at the inlet to water spray box, which improved performance and reduced build-up.

The plant was down for approximately one day to replace ten broken knives in the pug mill. One knife broke and the fragmented knife caused nine others to break. A new stainless steel die plate (1 ½" diameter holes) was installed at the extruder to replace the existing worn die plate. Contractors were employed to excavate and pave the area west of the CV building. In total, the yard area was extended by approx. 10,000 square feet.

. <u>4th Quarter 2006</u>

In October, the plant was down the entire month due to a scheduled maintenance outage by BPP. UA personnel entered the CV and completed removal of any internal deposits. An extensive list of maintenance and repairs were completed throughout the facility, including thorough cleaning of electric room and servicing of all wiring, inspection, and lubrication and service of all plant gear boxes and conveyor belts, removal and modification of ductwork at numerous locations, cleaning and servicing of the water spray box at the pugmill, thoroughly clean and replace knives in both the pugmill and pugsealer, replace extruder liner with one-piece prototype design, and re-configured bin vents for weigh feeders, repaired condensate pump, replaced flange gaskets on steam skid, replaced and upgraded thehardware on the rotary distributor, drained and cleaned process water tank, recharged and recirculated the CV, and replaced hammers in the lime pulverizer. In addition, mechanical contractors installed adjustable flow dampers at the base of the CV, a pneumatic slide gate at discharge of F250 recycle bin, and wear-resistant elbows on the CV recirculation piping.

In November, the UA plant was down most of the month as BPP extended its scheduled outage due to turbine problems at restart.

Approximately 769 tons of dry SDA were processed this month. Numerous velocity profile tests were conducted as material was recirculated through the CV. The new flow CV flow dampers were adjusted as required to achieve uniform velocity in each of the four cans. In total, more than 1,000 tons were recirculated through the CV. During a trial start-up of the plant, the horizontal impactor incurred significant damage. The damage was assessed, replacement parts were expedited, and all necessary repairs were completed.

At mid-month, a large trommel screener was procured and used to screen the entire inventory of product in the yard (~1,500 tons). The screening was necessary to eliminate chunks that had formed in the stockpile. The plant resumed processing SDA on a limited basis on November 24. BPP's production of SDA remained minimal due to switchgear problems and mild weather. Consequently, there were no attempts to charge the CV this month.

In December, approximately 6,106 tons of dry SDA were processed through the plant. Unseasonably mild weather caused BPP to operate at reduced loads this month. Consequently, UA operated at lower throughputs to match BPP's SDA production. In addition, the plant was shutdown on Christmas Day. Aggregate production for the month totaled 1,276 tons.

Initial attempts to charge the CV revealed a loose motor lead and a worn sprocket on bucket elevator BE250 and a damaged discharge chute on the secondary screen. Both conditions were repaired as necessary. Additional maintenance was required to clear build-ups at the tumbler and the CV pant legs. At mid-month, it was determined that the internal ribs of the one-piece extruder liner were badly worn and restricting flow through the extruder dye plate. The worn rib sections were removed and replaced, which remedied the problem.
Engineering was on site throughout the quarter to support maintenance activities, plant operations and supervise contract workers.

In October, an engineering representative for the manufacturer of the wet scrubber was on-site to review/analyze operational problems with the scrubber. A baghouse engineer was consulted regarding a revised ventilation system for the top of the CV. The new design would employ cartridge dust collectors (on CV cans) to replace the wet scrubber. An order was placed for four cartridge dust collectors and a 100 kW duct heater. A purchase order was issued and preliminary design discussions for a twin shaft pug mill began with engineers from the fabricator.

Following an inspection by the VADEQ in September, a detailed response was prepared addressing documentation, dust collector maintenance, and operator training.

In November, discussions continued with DA and other consultants on the design details of the new twin shaft pug mill. Approval drawings for the pug mill were finalized and signed on November 17. An order was also placed for a 100 HP variable frequency drive for the new pug mill. The layout and structural steel for the new pug mill were reviewed with engineers for structural design and drafting. A meeting was held with mechanical and crane contractors to review logistics of the pug mill removal and installation. Electrical switchgear and supplies were specified for the new duct heater for the top of the CV. UA received and reviewed vendor quotation for a new screw conveyor required for the new recycle feeder. Weigh feeder approval drawings were not yet received.

In December, pugknives for the new pug mill were ordered, powder coated at a local shop, and delivered to the fabricator. Weigh feeder approval drawings were received and reviewed. A change in the orientation of the rotary valves was submitted to the weigh feeder manufacturer. Equipment layouts for new pug mill, catwalk extension, new weigh feeders, and access platform for the K250 recycle feeder were reviewed with engineers in drafting. At month's end, UA engineers traveled to the pugmill fabricator's shop to inspect the pug mill and tour their facilities.

The QA/QC program was implemented in each shift during integrated run for aggregate production in December. Throughout production, the quality of produced materials was monitored at three separate locations (extruder, CV charge and CV discharge). Samples collected must meet established quality specifications for continuing curing vessel charge and aggregate production. Technical support was provided for air classifier operation optimization, start-up during initial CV charge, aggregate quality improvement, recycle quality evaluation, and management of Birchwood SDA silo level. General housekeeping was conducted throughout the facility. The vibratory feeder on the CV recirculation system was cleaned and re-positioned to improve throughput. The rebuilt eductor for the plant baghouse (BF550) was re-installed. Contractors completed installation of a pressure regulating station on the incoming steam line. The new steam system was brought on-line and is performing well. A failed process water pump was examined and repaired as necessary. Communications and paperwork were completed as required to dispose of a radioactive source (Cesium 137). The source was part of nuclear belt scale installed on an unused conveyor belt.

Contract electricians completed routing conduit and power required for the new 100 kW heater at the top of the CV. The pressure regulator and control valve for the additive system were serviced this quarter. A failed bearing on belt conveyor L510C was replaced.

APPENDIX “C”

QUALITY ASSURANCE & QUALITY CONTROL

QUALITY ASSURANCE AND QUALITY CONTROL PROGRAM

1. “Green” Extrudate

a. Penetrometer Reading

Test Procedure: Collect ten pieces of “green” extrudates. Measure penetration resistance of each “green” extrudate by applying penetrometer perpendicularly and slowly to the extruded product until the penetration reading stop. Use ¼” diameter tip for extrudates with 1 ½” diameter or lower. Record penetrometer reading (in Kg/Cm^2). Calculate average reading of ten reading for comparison.

Limits: The minimum allowable average reading is 1.0

Action: Record penetrometer reading. Penetrometer reading below the minimum specification (i. e., 1.0) must be brought to attention of plant manager or the responsible person in the shift.

Sampling Point: Outlet of extruder dye

Frequency: Once per hour or more if requested by plant manager or the responsible person in the shift during start-up operation.

b. Deflection and Structural Integrity

Test Procedure: Collect two pieces of “green“ extrudates. Measure deflection of each extrudate by dropping it from a height of about ten feet. Observe percent of deflection, broken pieces and cracks on the surface of the extrudate.

Limits: The maximum allowable deflection is 30%. No broken pieces are allowed.

Action: Record percent of deflection, broken pieces and cracks for comparison. Deflection exceeding the maximum specification (30%) and any broken pieces must be brought to attention of plant manager or the responsible person in the shift**.**

Sampling Point: Outlet of extruder dye

Frequency: Once per hour or more if requested by plant manager or the responsible person in the shift during start-up operation

c. Moisture Content and Temperature

Test Procedure: Determined with rapid moisture analyzer

Limits: The maximum allowable moisture content is 34% (dry basis)

Action: Record moisture content. Extrudates exceeding the maximum moisture specification (i. e., 34%) must be brought to attention of the plant manager or the responsible person in the shift. Record the extrudate temperature for comparison.

Sampling Point: Outlet of extruder dye.

Frequency: Once per hour or more if requested by plant manager or the responsible person in the shift during start-up operation.

2. Blend of Extrudates and Embedding Material (Curing Vessel Charge)

a. Temperature of the Blend

Test Procedure: Collect a blend of extrudate and embedding material from the top of belt conveyor L-410A with a two-gallon bucket during curing vessel charge. Insert a thermocouple in the bucket for temperature measurement.

Limits: The minimum allowable temperature is 150 °F. Temperature below the minimum specification must be brought to the attention of the plant manager or the responsible person in the shift.

Sampling Point: Samples collected from the discharge on the top of belt conveyor L-410A during curing vessel discharge.

Frequency: Once per hour or more if requested by plant manager or the responsible person in the shift during start-up operation

b. Penetrometer reading of extrudate

Test Procedure: Determine penetration resistance of extrudates with the same test procedure as that in “Green Extrudate” (1a.).

Limits: The minimum allowable reading is 2.5

Action: Record the penetrometer reading**.** Penetrometer reading below the minimum allowable reading (i. e, 2.5) must be brought to attention of the plant manager or the responsive person in the shift.

Sampling Point: Samples collected from belt conveyor L 410A near the top of curing vessel.

Frequency: Sampling as in 2a

c. Moisture Content of Embedding Material

Test Procedure: Separate embedding material from extrudates with a 16 mesh screen. Store the –16 mesh sample in a zipped bag. Determine moisture content of embedding material with rapid moisture analyzer.

Limits: The maximum allowable moisture content is 17% (dry basis)

Action: Record moisture content. Moisture content exceeding the maximum specification (i. e., 17%, dry basis) must be brought to attention of the plant manager or the responsible person in the shift.

Sampling Point: Samples collected from the top of belt conveyor L-410A prior to enter the curing vessel.

Frequency: Sampling as in 2a.

3. Recycle

a. Moisture Content

Test Procedure: Determined with rapid moisture analyzer.

Limits: The maximum allowable moisture is 12% (dry basis).

Action: Record moisture content. Moisture content exceeding the maximum specification (i. e., 12%, dry) must be brought to attention of the plant manager or the responsible person in the shift.

Sampling Point: Samples collected from Screw Conveyor L-250B under Recycle Bin F250.

Frequency: As requested during integration operation**.**

4. Spray Dryer Ash

a. Carbon Content

Test Procedure: Comparison of ash color with standards with known carbon content.

Limits: The maximum allowable carbon content is 8%.

Action: Record carbon content. Change of carbon content over 1% must be brought to attention of the plant manager or the responsible person in the shift.

Sampling point: Samples collected from screw conveyor L-120A underneath SDA Day bin F120.

Frequency: Every 24 hours or more if requested by the plant manager or the responsible person in the shift during start-up operation.

b. Hydrated Lime

Test Procedure: Procedure as listed in ASTM method C25 by titration

Limits: No limit on hydrated lime content.

Action. Store the sample in a zipped bag. Mary Matthews will determine SDA hydrated lime content by titration.

Sampling Point: Samples collected as in 4a.

Frequency: Every 24 hours or less if requested by the plant manager or the responsible person in the shift during start-up operation.

5. Blend of Cured Extrudates and Embedding Material (Curing Vessel Discharge)

a. Temperature of the Blend

Test Procedure: Determine temperatures of discharged materials on belt feeder L-410F by inserting a thermocouple in the discharged material in each belt.

Limits: No limit on temperature.

Action: Record maximum and minimum temperatures.

Sampling Point: Samples collected from belt feeder L-410F at bottom of curing vessel.

Frequency: As requested during integration operation.

b. Moisture Content of Embedding Material

Test Procedure: Separate embedding material from cured extrudates with a 16 mesh screen. Store the –16 mesh sample in a zipped bag. Determine moisture content of embedding material with rapid moisture analyzer.

Limits: The maximum allowable moisture content is 12% (dry basis)

Action: Record moisture content. Moisture content exceeding the maximum specification (i. e., 12%, dry basis) must be brought to attention of the plant manager or the responsible person in the shift.

Sampling Point: Samples collected from belt conveyor L-410B and L-410D at bottom of the curing vessel.

Frequency: Sampling as in 5a.

c. Hydrated lime content of Embedding material

Test procedure: Procedure as listed in ASTM method C25 by titration

Limits: No limit on hydrated lime content for initial integration run

Action: The –16 mesh sample should be stored in a zipped bag. Mary Matthews will determine hydrated lime content.

Sampling Point: Samples collected as in 5a.

Frequency: Sampling as in 5a.

6. Aggregate Products

a. Unit Weight of Crush Aggregate

Test Procedure: Procedure as listed in ASTM method C 29

Limits: Per contract.

Action: Samples not meeting customer's specification must be brought to the plant manager's attention.

Sampling Point: Composite sample collected from automatic sampler (AS-510) at belt conveyor L510A or aggregate stockpile.

Frequency: Per customer's request.

b. Size Gradation of Crushed Aggregates

Test Procedure: Procedure as listed in ASTM method C136.

Limits: Per contract.

Action: Samples not meeting customer's specification must be brought to plant manager's attention.

Sampling Point: As in 6 (a).

Frequency: Per customer's requirement.

Photographs

Demonstration Plant Construction (Sept., 2003)

Demonstration Plant Operation (Aug., 2006)

Demonstration Plant Construction Curing Vessel and Curing Vessel Building

Extrusion of Spray Dryer Ash at Demonstration Plant

Masonry Production Testing at The National Concrete Masonry Association

Commercial Concrete Masonry Production